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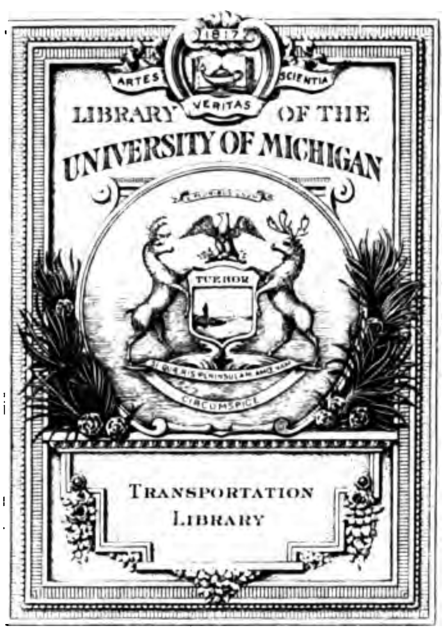

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PREFACE.

It is now nearly three years since the Panama Canal was taken over by the American Government and intrusted to a Commission under the special direction of the Secretary of War. The sum of one hundred and forty-five million dollars has been authorized by Congress, and the official estimate for the waterway's completion totals nearly one hundred and forty millions. Fifty-three millions have been appropriated of which almost forty are spent; the balance is to last until July next. The call for the coming fiscal year has been published. It is again twenty-five and a half millions. Of the original grant there will be left eighteen months from now but sixty-six and a half millions to serve the entire expenses during the seven years remaining of the estimated construction time. Were the rate, when the work is in full swing never above this, the deficit would still amount to more than a hundred millions. For actual contract execution as now proposed there remains after subtracting the expenditures which the Government itself has undertaken less than forty-two million dollars.

With an outlay of two hundred and fifty-six million dollars the French completed two-fifths of the excavation of their small canal. With an outlay of nearly forty millions the Americans during three years have achieved but one-eightieth of the mass to be handled for their large canal. The excavation has been in the upper materials; the submerged rock, the indurated clays, the sliding clays, the massive concretes—these are almost untouched.

30,000 men are now upon the rolls. A labor contract is ready for signature calling for Chinese to the privileged maintained number of 15,000 requiring the transportation and repatriation, dead or alive, of 95,000 men. This is not half the further quota needed for realizing the 85 foot lock project under the proposed system. With the present labor pay-roll of approximately $1,000,000 per month, the wage alone will mount in eight years to $96,000,000.

The culmination of half a century's struggle came in the law of Congress for a lock canal at Panama. A strong effort was made in both houses to secure an endorsement of the special design known as the 85 foot project. But its integral features were shown before the Senate Investigating Committee to be so hazardous and unsound that no legislative acceptance could be won for it. The vote endorsed the general lock type only.

Preface.

The challenged elements were not of minor details; they concerned the very being of the Canal itself; lock flights unparalleled and planned with only four borings for data; one-tenth of the waterway a mere paper location, without any borings or even a survey for data; stupendous dams likewise unprecedented under tropic conditions, the hugest located again as to one-seventh of its length with no borings or explorations whatever for data; lock lengths shortened from 1000 to 820 usable feet to fit the Procrustes beds of the hills; estimates based upon the impossible proposition of excavating indurated clay-rock with hydraulic dredges; dam building conditioned upon pumping material to a height of 80 feet after piping it a distance of six thousand, though the highest yet achieved has been a lift of 35 feet at a distance of 2000; entrance channels located directly over submerged reefs; breakwaters with foundations in unknown and unsearched depths; silt-jelly in the heart of the great dam and the dam the heart of the project—such were some of the arraignments.

So utterly did the defense of its assailed features break down in the Senate examination that no endorsement whatever of the specific plan could be secured from Congress.

Now before legislation or the Executive can safeguard the waterway an omnibus contract big with fate is proposed for the Canal.

The facts of the Panama situation and technique have never been brought to general realization, but its excesses have already begotten among engineers a distrust and disquiet such as have never before attended a national work. What confidence still remains to the people at large exists only because the facts have been uncomprehended and obscured.

To the public over whom in every such case the particular profession concerned stands as guardian and protector, there should be pointed out so clearly that whoso runs may read, the facts inherent in and inseparable from this proposed scheme and its execution. It will not do to sit silently till in a brief time transgression works retributive destruction and defied law exacts its inexorable penalty. It must be insisted that laws, economic and natural, shall not be transgressed unto the undoing of our vast national undertaking.

This series of papers will briefly, in untechnical language, analyze the features proposed, to the end of disclosing to what this country is being committed at Panama. They will interpret the facts to the goal that our world waterway and its construction shall be yet directed to security and success.

THE SPONSORS FOR THE HIGH DAM CANAL.

The sanction for any technical measure is found in the quality of professional judgment supporting it. Indorsement must come from expert authority proficient in the specialty. An hydraulic question cannot be validly judged by doctors, attorneys, or railroad managers; it must be weighed by adequate hydraulic and navigating skill. This is the element of capacity or knowledge. Next, quality incorporates the element of character. The expert must possess the intellectual and moral fiber which can arrive at a clear, correct and final decision, which shall carry his highest unbiased convictions. It is surely in order to examine and weigh the technical authority upon which rests the project for this great international waterway, which will represent, when completed, the costliest public improvement executed in all the history of the race.

Of the thirteen members constituting the International Board, a minority of five recommended this high level, multi-lock canal. The five included two engineers who had sat upon previous Isthmian Commissions and had publicly and ardently advocated, as the only right solutions for Panama, projects quite different from the one now supported by them. One of these had within three months published a book setting forth by the strongest arguments, and through his deductions from French data of Chagres discharge, his conviction that the high level type was unsafe, the sea-level type anathema and the four lock 61.5 foot the only correct solution. In the face of many years' denouncement and condemnation of an 85-foot summit level, he now votes for it, but his long testimony as to its perils compels him to dissent from the location of three locks in flight at Gatun. He begs the compromise of setting one of the locks at Bohio.

The other former commissioner testified before the Senate Committee that he himself, in person, designed and drew the Gatun three locks. He was under the painful need of confessing in the same testimony that, by some error, their usable lengths, which were given to the public over his signature as 900 feet, measured in these drawings, which the Minority and Commission had examined and accepted, 820 feet. (Senate Report, pages 1639 and 1854.) He was also four years ago one of the champions of the great masonry core Bohio Dam which the first competent borings sent to the limbo of the impossible.

A third member of the Minority voted four gigantic, unexampled earth dams, each, despite the great difference in conditions, modeled on his one relatively simple *chef d'oeuvre*.

A fourth was a specialist in operating locks. He was not eclipsed. He matched the dams in massive and quite unprecedented flights of locks. Both recommendations were brought by their size into the field of experiment.

The fifth, step-fathering here a high level design, is on public record in support of a sea-level tunnel scheme through the mountain of Darien as the solution for the trans-isthmian canal. He " most unhesitatingly recognized the practicability," etc., and he " believes that I can organize a body of the ablest contractors to be found in the United States who will do the work for these prices." He is opposed to locks and observes that he " need not take up the manifest advantages of an inter-oceanic canal without locks, because the *obvious* need not be dwelt upon." He abandons now the sea-level, tunneled, lockless, Darien-Mandingo of 1902 and advises a very high level, six-lock canal not at Darien, but at Panama.

This is the record of the Minority of the International Board of Consulting Engineers who formulated the plan. Next as to the Isthmian Canal Commission who endorsed and have undertaken to execute it.

The Commission had two members, the Chairman and Zone Governor, who are self-confessedly not engineers at all, civil or any other kind, not naval constructors, or navigators, or sea men. One is a railroad re-organizer, the other a very competent and successful governor. Being wholly without training or experience, they are quite unqualified for considering hydraulic questions or plans. It is a sacrifice of all chance for rational solution to have a great world technical problem like the Panama canal design decided by the opinion and vote of men, howsoever competent in other fields, thus fundamentally unfit.

A third Commissioner foreswearing his colleague's engineering goes to the sea-level. A fourth stands now with the high level, reversing himself, for he moved to adopt the sea-level scheme in the last Walker Commission. The fifth and sixth members served on the Commission of 1901, whose plans were made the basis of the canal purchase and the authorization of the Spooner Act. One million dollars had been put at their disposal for a thorough examination and report. They, like the Minority member, advised the massive masonry core " Bohio Dam " and announced suitable and ample rock foundations within available reach.

The ex-Chief Engineer's very first borings revealed that the rock upon which this central feature of their canal rested was not there, and the whole

Sponsors for High Dam Canal.

Bohio Dam project fell in a night. Likewise these two men together with their colleague of the Minority had condemned as unsafe at the Isthmus any dam which had not a masonry core founded on rock. Now, four years later, they vote to build an even huger dam of earth, on a spot which they themselves previously rejected, and they base it upon openly acknowledged alluvium. As they then gave learned opinions of the safety of the Bohio Dam, so now they heap up assurances as to the safety of their Gatun Dam.

Of the nine men, therefore, of the combined bodies, who being engineers, might supposedly speak with some authority upon this technical matter, one has gone to the sea-level; six have quite changed their previous public and studied published recommendations, while the two new men have voted their own specialties in colossal and quite experimental features.

A professional man's entire value lies in the accuracy and reliability of his opinion in any complex situation. The right diagnosing is the first indispensable, the right prescribing, the second. What can be said then of the two bodies, posed as experts of the first order, whose opinions and advices in a matter involving around $250,000,000, betray such radical changing and inconsistency. Can such decisions convince any one, or pretense longer mask the fact that they were and are at sea as to what to advise for the Panama canal and have engineered loose-handedly in confusion, perversion and compromise?

The deliberations of the International Board and Commission were over a great world question, purely technical in its nature. Its problems were supposed to be weighed and measured under no personal prejudices, or heritage of *amour propre*, by engineering principles alone. It was by inference a scientific Board, assembled as a highest court to judge by universal technical laws. An anomaly in this supreme tribunal was that, of the American judges all but two were already committed and on record in the deliberate and studied announcements of official government reports.

The many all over the world who are familiar with the long Isthmian engineering story will realize that the personal equation was still the deciding factor at luckless Panama.

The last throw of the die is about to be cast. The country should know to what it is being condemned in the integral features of the eighty-five foot project and its proposed contract. It may well be the hope of the nation that its Executive shall intervene in time or that Congress shall yet legislate to the rescue and the righting of the Panama Canal.

EXECUTION.

LABOR AND SANITATION.

When, three years ago, our Government took over the enterprise of the Panama Canal it was with all its proverbial enthusiasm. Our self-confidence was boundless. We would exhibit to the world how competent American business methods would put the waterway through. We had a subtle disdain for our predecessors—the impractical French! And we tinctured it with pity, the visionnaires! So we bought all their properties—channel, right of way, railroad, charts, machines, scrap heaps, and smiled, for we believed we had driven a Yankee bargain. One thing was overlooked, and the French with idealist generosity threw it in. It had cost them six times what we were giving for their whole investment—six times the money and their nation's honor. Yet truly for us it was, of all, the most valuable asset—their experience. Had we bought it at high price, it might have been prized and have been let yield us its precious saving service. But it too has been disdained and in blind obliviousness we head the old fateful way into the self-same pit.

" Laborers are wanted at Panama! " The call has gone out from the Isthmus for fifty years. In the closing months of the French regime light dawned and the word went forth—the minimum of men, the maximum of water-borne machines, and land plant invincible to rain. This was the final dictum of a generation's experimenting.

The whole gamut was run at the Isthmus by the pioneers of railroad and canal building. They began, in frenzied precipitate speed just as we, then called a halt to get ready, just as we. They proceeded next to house building, just as we, and gathered a very riot of useless equipment and purchases, just as we. They erected hospitals and infirmaries that were models, just as we; and their corps of physicians and nurses, disinfected and sanitized, just as we. The railroad began with the native Isthmian and the Jamaica negro, just as we; sampled the sons of toil from many lands, and ended with the coolie from Canton, just as we. And tragic enough it was, this Chinese experience. We have not arrived at it yet; we are only at the Jamaica negro stage.

The work of actual building is not truly on, yet the reports give thirty thousand men on the pay rolls. " Twenty steam shovels," the chairman announces, " are doing the United States work of four or five." The output of twenty-seven of these, and the digging of two or three patched-up dredges of the vintage of twenty years ago virtually represent the Canal excavation. The rest of the work is railroading, building, sanitizing and distributing the millions of dollars' worth of American supplies. The force far outnumbers that of the French at the zenith of achievement when their tremendous plant was digging everywhere from sea to sea.

M. Rousseau especially delegated by his Government, reported in April, 1886, that in the month of January it had required ninety-five hundred workmen using machinery of that date to excavate 637,000 cubic yards and estimated that proportionately it would take a force of 37,750 men to handle the needed output of 2,529,800 cubic yards per month in the dry.

These figures excluded the dredge work which he wrote " requires but a small personnel."

According to the latest published official U. S. report there were carried on the rolls in July last 28,000 men, of whom 25,000 were laborers and 3,000 white men. The Chairman makes the force now 30,000 men. The French never had so many all told by 10,000. Yet the superiority of modern methods, tools and labor-saving devices has been much vaunted. It has been one of the enigmas of the past year what this army was doing at the Isthmus.

Measured by the actual efficiency rate which the French achieved, of 70 cubic yards per month per man 27,000 laborers at Panama ought in January next at a similar output to be handling roundly 1,900,000 cubic yards. They did not make much of an approach to this rate last January, nor in the attempted spurts of May or July. The best month in the nearly three years' experience of American management gave 289,000 cubic yards. This represents less than one half the French output with over twice the French force. The facts appear to be that the experienced builders of Suez transplanted to Panama, got in results nearly four times as much efficiency per month per man as the Commission is securing, and the French sanitized, built houses, and tracks and installed plant as truly as we.

Recalling the French financial history this is surely a very serious condition and one concerning vitally and fundamentally the whole undertaking, especially as labor and superintendence are being paid much more than under the French system. If some radical betterment is not effected, the inescapable logic of the facts is that the waterway must cost many times what Congress has allotted to it.

The 85-foot plan as designed requires such profligacy of human labor in the excavation and distribution of material that if the authorities are thus crippled when it is only begun, what is to be expected later? There could hardly be discovered a canal project to which labor-saving, rain-defying, or water-borne plant is less applicable than to this scheme which so sorely needs it.

There are 110,015,000 cubic yards of excavation and embankment and such embankments! 43,480,000 cubic yards in the high Gatun Dam, the three Pacific Dams and the Railway Fills to be handled by " dry " methods.

Besides, there are 12,960,000 cubic yards of " dredging at 25 c." in Lake Gatun above the plane of 40 feet. There are also 1,680,000 cubic yards of " dredging at 25 c." in Lake Sosa above the plane of ten feet. To dredge 14,640,000 cubic yards after the lakes are full will certainly take a large plant two years, as the material is of a mixed and not particularly favorable character. Delay can be avoided therefore only by employing dry instead of wet methods and this brings the total to about 124,615,000 cubic yards. Allowing a man the efficiency of the French rather than the deficiency of the present system and rating him 70 cubic yards per month, would give for executing the canal the equivalence of 1,780,800 months work. But January is in the short favorable dry season and the difficulties of the wet season must be reckoned to diminish the output by 50% and hence to increase the time equivalence to 3,116,400 months.

To perform 3,116,400 months' work in a hundred months will take a force of 31,164 men. On such a basis at least 31,000 men will be required in addition to the present force of 30,000 presumably now fully employed or to be needed later for the sanitary and the vast concrete works. This totals 61,000. The Chairman of the Commission is quoted as saying that 75,000 men may be ultimately employed.

When the American Government took over the Canal and set about completing it, a certain general system of execution was selected with the Culebra cut taking precedence as the focus of attack, excavation in the dry for the process and the steam shovel for the adopted implement. This principle and method has been followed unbrokenly since. The estimates for the Canal's cost as made up by the 1901 Commission were based primarily upon this procedure rating the output at an efficiency which the tool was expected to attain. The Commission pressed by the need for getting results had two alternatives —to put through the work along the old lines by sheer force and weight of numbers in defiance of cost; or acknowledging the inadequacy of their system to adopt other and better methods. They chose the former. Hence again from the Isthmus has gone forth the Macedonian cry for more men! Where shall they be sought?

Labor is not coming from France—7,000 graves—the old lesson lingers. There is no English or German contingent, and no Irish brigade such as enlisted once for the Panama Railway struggle. The American negro reads too significantly to be lured and Argentine and New York are good enough for the Italians. Their Government, watchful of the fateful plan to which this Government is being committed, has passed the negative of its support to proselyting, while Japan, alive to the superficial temporizing over health with the swamps conserved as foci of disease, conditions her labor co-operation upon supplanting our sanitists with the surgeon-heroes of her own Manchurian army. Enlightened Governments are going to allow us their bone and sinew only when they are satisfied that these citizens will have every reasonable chance for health and survival. Contractors may accept imposed labor responsibilities, but when the inevitable crucial hour arrives it will be government arraigned at the bar of government. Failing, elsewhere, bids have just been received for, ostensibly, 2,500 Chinese with an option to call for enough to reach and maintain a contingent of 15,000.

We began with the native Panamanian, but we threw him over speedily and hailed the Jamaicans as the only laborers. We made them houses, the like of which they had never dreamed in, and brought them their own and inalienable wives—from Martinique. After three years, word is passed that " clean cabins, clean beds, clean food, pure water, light and sweet air and sewage are fatal to Jamaicans and their lungs give out." All the weedings and dozen strippings of tropic growth from Christobal to Corozal, all the mosquito netting and disinfecting and the Jamaica negroes reported only, the lazier, more shiftless, more sickly, till the authorities shutting their eyes resolutely to the vanished millions, turn the leaf silently that public attention be not disquieted and call the chapter closed. After the negro, the Chinese!

It is not the Isthmus—oh no! The chief engineer and a genial general testify that during their prolonged sojourns they have seen two, or at most, three mosquitos. The forests of Peru and the Dutch Islands are still ransacked for the alkaloid diet of the Canal army and its camp followers. It still takes the three daily doses of quinine for every man, woman and child in the Zone, but this is not writ large in the official reports. The capital letters are reserved for the " Yellow Fever," which has been " Stamped out." It has come stealthily and mysteriously and gone again a hundred times before, since the Spanish leeches wrestled with its death, for it is the passing visitant, not the dweller on the threshold. But even this grim presence our visionnaires report vanquished. The Augean labor of sanitizing at the cost of millions has become a cult—the cult that a narrow way through the trackless jungle and reeking swamps with the ends thereof at Colon and Panama, can be made so bare, so clean, so sweet, so free of creeping or winged pest than man may come and go with immunity past the sleeping city on Monkey Hill. Nature smiles at this Pyrrhic victory, proclaimed from the hill tops with the morasses unpierced and unattempted. But the Chinese are coming! They came before to Panama. "Matachin," dead Chinese town, keeps their story. F. N. Otis, the official guide, epitomizes one incident.

"The Chinamen, one thousand in number, had been brought to the Isthmus by the Company, and every possible care taken which could conduce to their health and comfort. Their hill rice, their tea and opium, in sufficient quantity to last several months, had been imported with them—they were carefully housed and attended to and it was expected that they would prove efficient and valuable men. But they had been engaged upon the work scarcely a month before almost the entire body became affected with a melancholic suicidal tendency, and scores of them ended their unhappy existence by their own hands. Disease broke out among them, and raged so fiercely that in a few weeks scarcely two hundred remained."

A contemporary, Mr. Tomes, published instructive details. He was invited down as one of the distinguished company to the inaugural.

"A terrible fatality attended the efforts of the R.R. Co. to avail themselves of the assistance of Chinese laborers. A ship arrived, and landed on the Isthmus over eight hundred after a fair voyage from Hong Kong, where these poor devils of the Flowery Kingdom had unwittingly sold themselves to the service of the railroad, perfectly ignorant of the country whither they were going, and the Chinese bore its fatigues and sufferings with great patience, cheered by the prospects of reaching the foreign land, whither they had been tempted by the glowing descriptions of those traffickers in human life who had so liberally promised them wealth and happiness. Sixteen died on the passage and were thrown into the sea. No sooner had the over eight hundred survivors landed than thirty-two of their number were struck down prostrate by sickness; and in less than a week eighty more laid by their side. The interpreters who accompanied them attributed this rapid prostration to the want of their habitual opium. This drug was then distributed among them, and with the good effect of so far stimulating their energies that two-thirds of the sick again arose from their beds and began to labor. A Maine opium law, however, was soon promulgated, on the score of the immorality of administering to so pernicious a habit, and without regard, it is hoped, to expense, which, however, was no inconsiderable item, since the daily quota of each Chinese was fifteen grains at a cost of at least fifteen cents. Whether it was owing to the deprivation of their habitual stimulus, or the malignant effects of the climate, or homesickness or disappointment, in a few weeks there was hardly one out of the over eight hundred Chinese who was not prostrate and unfit to labor. The poor sufferers let the pick and shovel fall from their hands and yielded themselves up to the agony of despair. They now gladly welcomed death, and impatiently awaited their turn in the ranks which were falling before the pestilence. The havoc of disease went on and would have done its work in time, but as it was sometimes merciful and spared a life, and was deliberate though deadly, the despairing Chinese could wait no longer, he hastily seized the hand of death and voluntarily sought destruction in its grasp. Hundreds destroyed themselves, and showed, in their various modes of suicide, the characteristic Chinese ingenuity. Some deliberately lighted their pipes and sat themselves down upon the shore of the sea and awaited the rising of the tide—grimly resolved to die, and sat and sat, silent, unmoved as a storm beaten rock, as wave rose above wave until they sank in the depths of eternity. Some bargained with their companions for death, giving their all to the friendly hand which, with a kindly touch of the trigger would scatter their brains and hasten their doom; some hung themselves to the tall trees by their hair, and some twisted their queues about their necks with a deliberate coil after coil. Some cut ugly, crutch-shaped sticks, sharpened the ends to a point and thrust their necks upon them until they were pierced through and through. Some took great stones and leaped into the depths of the nearest river. Some starved themselves, some impaled themselves, and thus in a few weeks scarce two hundred Chinese were left of the whole number. These were sent to Jamaica."

The rate of mortality is given in the early records as, for natives of all races, 1 to 50; for negroes, 1 to 40; for Europeans and Australians, 1 to 30; for Chinese, 1 to 10.

These are the Celestials from the Sacred River, for whom our authorities are asking bids. Each man is to be indentured separately, and conflict is to be avoided with the contract labor law. In framing that act it never entered into the minds of American legislators that this Government, rooted in freedom, and in the bloodiest war of modern time sealed anew unto freedom, would or could be precipitated back into the slavery of the indenture system. The successors of Wilberforce, after overturning the ministry which had affronted the moral sense of Britain, have just undone it and given it the coup-de-grace in its last English foothold—South Africa. But it seems that a Commission of the country which Lincoln saved is to commit the nation without a protest to this iniquity. The slave gatherers of the indenture system are invited to transfer to our territory their traffic, and under the Stars and Stripes shall man's wage and life be bartered and bound anew. At Panama, in these coming years of God, again, after half a century, are the Chinese victims, "contracted" and helpless in an alien land, to see their kin mowed down by the reaper of the swamps till they, too, yield their souls to despair, and go, like their brethren, the way of suicide to release. " Each man is free," you say? Free in the jungle, " under contract," with no ships and no money to get away with, surrounded by police " to keep order " and to enforce the command of " Work, or leave and starve "? And the Chagres fever decimating them as of old! Will their situation be any less maddening than that of their predecessors at Matachin?

The upholders of this new slavery are vouching the delusion that there will be no Chagres fever, no pestilent malaria. They have persistently maintained that their vast force have succeeded in sanitizing the zone. But the facts do not corroborate these representations. After nearly three years along the blazed trail of cleaning, whitewashing, nightsoiling, fumigating, screening, weeding, sewering and reservoiring, the rainy season comes again, and the age-old tale begins. Listen to it.

The cruiser Columbia takes three hundred marines to help supervise the elections of the Panama Republic. They stay a month, and one hundred and sixty-five come back abed with malaria, and yet how carefully was their health watched and husbanded. It is the same old percentage disclosed by the naval reports of the many other sojourns, years before the sanitizing and the " cult " began.

And again :—

Despatch of August 1, 1906, to the New York *Herald*:

> " This rainy season has been a heavy trial on the canal builders, the railroad and the sanitarians. There has been a riot of malaria, all the departments being hampered with so many men in the hospital. Colon and Cristobal have had the worst of the plague of malaria and never since the former has been a town has there been such a condition of mud and impassable streets."

> " EPIDEMIC ON STEAMER. THREE OF CREW DEAD AND SIXTEEN OTHERS IN HOSPITAL."
>
> Quarantine Officials Declare Tropical Ship is a Menace to Health of all Ports and Cannot Dock at New Orleans—Only Two of Crew Immune from Malignant Fever
>
> " New Orleans, La., August 4, 1906. The steamer Whitehall from Colon was to-day declared a menace to the health of all ports and orders were given by the State Board of Health to hold her indefinitely at the Mississippi River quarantine station. The Whitehall has one of the worst fever epidemics on shipboard in the records of tropical shipping, having arrived here two days ago with most of her crew ill with Chagres fever. With the death to-day of the steamer's second officer, three of her complement of twenty-one men have already died and sixteen others are in the hospital. Quarantine officers say that when the Whitehall entered the Mississippi River with scarcely enough well men

> to run her, so great was the amount of dirt and swarms of flies on her decks that the nerves of experienced physicians were shaken as they boarded her. The steamer will not be permitted to come to New Orleans even after the fever is cured."

This rainy season has therefore indisputably brought the usual riot of malaria.

But the down-bending curve on the monthly health diagram will recur in October and November, when the momentous official visit comes—the curve telling anew the story of the season and paralleling the regular records of the French regime.

Then there will be triumphantly heralded as last year another Pyrrhic victory over Chagres fever, till the spring and the rain mock next the boast and the illusion.

Daudet, in one of his stories, has personified a forest on the flank of a river. While the forest slept its winter sleep some overdaring pioneers effected a footing. But the spring came and the rains and the sun. They and the earth whispered together and sent their legions of vegetation which overwhelmed the clearings and the cabins, drove the settlers to the water and obliterated all traces of the invasion. Panama has a jungle forest which in a few weeks takes back dominion of every uncontested foot. To-day a corps of about five thousand men are continuously engaged in fighting vegetation. From the reeking soil of the noxious marshes issue unendingly the visible and the invisible presences which wage its battle and take its toll of health and life. The forest and its microscopic myrmidons stop only at the water. Sovereignty can be permanently wrested from it by this one agency alone—water—water which shall drown deep its pestilence and its power. The keynote to salvation here Nature has herself appointed. The deluges of rain through nine months of the year are her dominating and determining condition. Why will men not ride and rise on a submissive alliance rather than futilely combat? It has been recently remarked by the Chairman of the Commission that so demoralizing and incapacitating have the rains proved this year that he believes the Panama Canal will have to be prosecuted during dry seasons only. If this defeat-confessing judgment rules, then of course thirty-six years are to be allowed for its construction. And how many millions of dollars additional must be reckoned to pay the hosts of laborers accomplishing next to nothing through these nine wet months of the year?

But the Chinese are signalled. The death rate of Chinese at Panama in the former years of their employment is given as was said at one in ten. Waiving this statistic let us reckon their mortality only at that of our own carefully tended and safeguarded army and navy—7%; the percentage of loss from chronic ill health is of course much higher. A further important point, which these long years of experience have attested is, that after a serious attack of illness at the Isthmus men have permanently lost their efficiency, to such a degree that they must be gotten rid of and superseded. Dumas, the last French chief engineer, and several others, give testimony to this effect.

An authority of 1855 writes:

" The railroad company are so far conscious of the debility engendered by a residence on the Isthmus that they refuse to employ those laborers who having gone to a healthier climate return to seek employment. It is found such are unprofitable servants and yield at once to the enervating and sickening climate. The enterprise requires all the vigor of unweakened sinews and of pure wholesome blood."

The U. S. sanitation records of last July give 4% that month at Panama, in hospital, when almost no excavation work was being prosecuted and the pestilent swamps were not yet being dug through at all. " Malaria is the great peril because four out of five of all hospital patients are suffering from some form of malarial fever."

The French history confirms, next, that the number of laborers who persisted longer than two years at work on the Isthmus were so few as to be trifling. A continuous stream of men poured in and out and the problem was forever the same—how to replace the incapacitated and the discontented, and keep the quota needed.

Mindful of this lesson, the Chinese are to be indentured for a two year term of bounden service. Contemplating the rainy season hospital record of 48% per annum, the fact that Chagres fever or malaria once well in the veins lowers the already low efficiency of labor to the point where it must be replaced by new blood; the discontent of Chinese labor in an alien land whose language and customs are strange, under a lately boycotted flag, whose barring restrictions have banished them from all its territory except this zone where none save black labor can be induced to dig and live; in the summary of all these aggravated elements the former history is not likely to be reversed. The number willing to re-enlist and sufficiently untouched by disease to be selected for retention beyond the two year period will be too few to be worth calculating upon. But let us figure the best chance.

The contingent of laborers, which, at the relatively high rate of the French output in 1886, must be kept at the Isthmus in addition to those now employed was shown to be over 31,000. If the efficiency during the three years past be taken as a standard it must be very much higher. If, next, 7% are to die and even the very inadequate proportion of three to six per cent. per month be for longer or shorter periods, retired to hospitals and homes of convalescence, it is ultra conservative to estimate that 8% of the force besides those who die will have to be repatriated because enfeebled. To maintain a force of 15,000 Chinese at the Isthmus then something like this must be faced.

In nine years there must be brought, roundly, 95,000 Chinese of whom 9,500 will die—10,500 will be invalided home; 67,500 (15,000 at 50% per annum) will enter the hospitals and there will be 190,000 fares across the whole Pacific Ocean. If further a force of 31,000 Chinese is required—a need more than which must exist in order to complete the excavation in nine years, especially if the recruiting in the West India Islands falls off the above figures will be much overdoubled. The situation is truly interesting.

No race stampedes in the face of mysterious and unrelenting pestilence or fumigation quicker or more desperately than the Chinese. The frantic flight of 70,000 from plague and disinfecting in Hong Kong in a few weeks in June, 1901, is a vivid example. Verily the white doctors and white nurses and the police at the Isthmus will be fully employed. If instead, these peons of this free government are to be left to their own medicine-men, with their witch-cauldron concoctions, their prayer wheel and demon remedies, it were well indeed for whites and blacks to leave when the coolies land, for there must come a situation as damning and damnable as could be conceived. This is their labor solution and its involved health situation.

When it is realized that our navy statistics extending over a long series of years, give for subtropical stations such as the Philippines and Panama, the chances for health to men afloat as against men on land 12 to 1, there is surely pointed a moral which the most perverse must some time heed. The way of labor and of health at the Isthmus is the way not of land but of water. Let the land area to be attacked and to be traversed be made the narrowest possible and in the least time possible. Let the land area to be submerged under lakes, rescued to health and eliminated from labor ashore, be the broadest possible and the submergence be secured the soonest possible.

These labor and health problems are so vast and fateful that regard to them should be reflected in the canal plan and its method of execution. The right way to meet the sanitation situation is to bury quickly the disease-breeding swamps under lakes. Physicians and hospitals will always be required and they should be the most competent and most perfectly equipped possible. That those in charge at Panama are skilled and are doing their uttermost is fully conceded. But physicians and hospitals should be as supplements to radical sanitary engineering which alone can eliminate the sources of infection. The efficient solution of the labor situation is to reduce to the minimum the number of men demanded, by enabling floating machines to attack as much of the canal length as is at all practicable.

No design meets this situation at all comparably with the one which creates first Lakes Chagres and Panama reducing the land width to the distance from Pedro Miguel to Tavernilla 16 miles in the first year. Forty-seven miles of width cut down to 16 miles in twelve months would augur a living chance for the Canal. A year later by impounding but fifteen feet of water at Gatun the land width would become reduced to the distance between Pedro Miguel and Obispo, eight miles.

These dispositions would leave a relatively small land force at the Mindi, Gatun and Sosa locations and between Pedro Miguel and Obispo. The dry Culebra excavation should go to the place of least rain-fall on the Isthmus—the water front of Panama. No more than 2,000 men to the mile can be effectively worked along the Culebra cut, so 16,000 men all told should excavate the central mass, and no Chinese are needed, if the right plan and plant and procedure are adopted.

The 85-foot lock project has two lakes which inherently cannot be realized or filled with water until after the nine years of construction and the uncalculated ones of delay. During all this interval the swamps shall have their unhampered way and thousands of ruined lives pay the price of mistake. It has never been the hills or the seas, but the low fever-hiving morasses which have overcrowded Panama's ghastly mate to Monkey Hill, naively re-christened by the Medical Board " Mount Hope." The commission is preserving the morasses from Mindi to Gatun and from Gatun to Obispo, while they transport at unnecessary cost in lives and money and deplorable excess of labor and put into the Gatun Dam and locks and railway fill, fifty million tons of shovelings and dredgings, stone, cement and steel and drag more millions upon millions of tons of railway, canal and commercial freight across the Isthmus.

The central mass must be worried out mostly in the dry, but why hurl the army to a frontal attack when there is a saving way to flank?

Here again as in every other feature, our authorities refusing the plain lesson of experience insist upon threshing out failure anew. The French were carried away once by the American steam-shovel propaganda. They ordered numbers of them only to discover as these engineers are in turn discovering, that the steam-shovel system is not at all at Panama under harrassing tropical conditions what it is on a western prairie. In the first confident ardor, scores of these were ordered and now after all the deluded but basic calculations of the Board and Commission have been founded upon them, " the chief engineer is casting about for a method which is less affected by the rainy season."

Execution.

The Culebra was likewise through the first years the mountain that focused French effort. But after long experience they learned the lesson of better attack and at the end machines afloat were eating into the Canal from almost every point that could then be made available. The present system one might think had surely tested itself, but despite the record it is to be perpetuated.

THE CONTRACT.

Contractors are wanted at Panama! This call likewise has gone often from the Isthmus in fifty years. After " conferences with twenty-five representative firms and bankers " the fruitage of counsel is set forth. Great stirring is announced in contract circles and eager competition is promised.

All over our land executives are strained day and night directing the vast aggregate of enterprises in the most prosperous epoch of all our annals. Everywhere managements are struggling to secure more and more efficient lieutenants and laborers, and are fighting for deliveries of machinery and materials which are more difficult and delayed than ever before in business history. Contracts of many varieties choke the market. First grade organizations are turning down a dozen to one which they undertake. East, West, North and South, from Mexico to Saskatchewan, the same activities prevail and demand is far beyond the power to supply or execute.

Throughout the world contracts are under a general standard system, hammered into form in the travail of the slow business evolution of centuries.

In this contractor world move thousands of able men, willing to truly serve their country, ambitious for themselves, jealous of the names they have made synonymous for achievement and honorably confident from past success, of the power to measure up against the construction of public works.

These contractors have their bondsmen who bank upon their fidelity and ability; their large backing of capital balanced on their judgment and safeguarded in their caution; their devoted staffs, their shifting armies of toil whom they as generals direct. Theirs is the task of actual execution at whose bar, plans and designs and all engineering meet their final test. They deal not in glamor, the pawns upon their board are cold hard facts. They must sift and build upon realities.

Into this arena comes a herald proclaiming the terms upon which such an one may joust with fate for fortune and life at Panama.

He investigates first the adequacy of the money named to cover the work, second the legality and quality of the transaction, and third the size and security of his profits. He sees a " Form of Contract," not on the old tried lines but nevertheless inviting on its face. He has met exceptional clauses before, and clauses with a bark and no bite. He prejudges no bitterness.

The Contract.

The first question for his analysis becomes what amount of money legally at disposal has the Commission got, to pay for what he may contract to do. His summary figured to January 1, 1907, when the contract may be ready for signature runs thus:

The Spooner Act appropriated........................$145,000,000

The 85 foot, six-lock project exclusive of sanitation and Zone Government, but including 20% for administration, engineering and contingencies was estimated to cost..$139,704,000

This allows for sanitation and Zone Government a margin of...$5,296,000

The 20% reserve is virtually a trust fund for other speci- $23,284,000
fied purposes, so deducting it we have..............$116,420,000

This is the total construction sum. Congress has appropriated all told:

First	$10,000,000
Second	11,000,000
Third	5,500,000
Fourth (to last till June 30, 1907.)	25,456,415
Panama Railway	1,000,000
	$52,956,415

Of this $12,728,207 is inferentially Jan'y 1st still in hand, and there is spent or bespoken........................ $40,228,208

which leaves... $76,191,792

But the Commission proposes for the present to omit the breakwaters and as in duty bound must reserve their estimated cost $5,000,000, which deducted leaves $71,191,792. This then is the sum out of which are to be paid:

Item 1. The outlays of the Government on what it undertakes to do collaterally with the contractor and for him.

Item II. The contractor's costs.

Item III. The contractor's percentage profits.

In Item I are embraced:

" All plant "—only part of which is on hand, or ordered.

" All raw materials of construction," sand, stone, etc.

" Lock mechanism and safety appliances."

" Cement, explosives, oil, fuel, coal, electricity."

" Quarters, warehouses, offices."

" Telegraph and telephone service."

" Terminal trackage, yards, docks."

" Water, repairs and renewals of plant."

" Shops, supervision, inspection, etc."

Contemplating the quantities and scope of expense embraced in each element of this long list the query becomes to the contractor, how much from the $71,191,792 can become available for his costs and profits?

He recalls that the old French company furnished to its contractors the important plant and materials, houses, barracks, etc., just as this Commission proposes. The record attests plaintively that incessant demands and claims produced unending troubles and the Company's actual outlay to fulfil its part amounted to $3,420,000 per annum (page 58 Rapport). Theirs was a much smaller waterway. If then the long schedule of Item I be reckoned at even the very inadequate figure of $3,000,000 per annum, nine years would demand $27,000,000 to be taken from $71,191,792.

Next this 85-foot scheme is very different from the 1901 designs upon which the appropriation was made. It has several costly incidental adjuncts. One of these is removing from the valley and rebuilding on higher slopes the Panama Railway. The Commission allotted to this $3,700,000.

The railway with its costs and outstanding bonds bearing high interest represents a Government investment of over $20,000,000, or as much as we paid Spain for the Philippines. " The construction of the Canal will necessitate building thirty-five miles of new road at an estimated further cost of $3,700,000. It is thought that not a dollar of this can be saved, though when the canal is finished the railroad will probably become almost useless."

So in the most optimistic view there is assignable to taking care of all the contractors costs and profits, $44,191,792. If there be allotted to his work on the railway change around $2,191,792 there is left to the canal for its completion and opening,—for its vast works of excavation and embankment, its dams, masonry, concrete, installations, etc., but the sum of $42,000,000.

The contractor is surprised, a little. How adequate is this? The French consumed $256,000,000 and had two-fifths of the excavation of their small canal finished. The masonry was untouched. The American management has expended forty millions and has achieved one-seventieth of the remaining "dry" earth and rockwork and none of the masonry of their much larger weterway. In nearly three years with a force which has mounted to 30,000 men and purchases and outlays which have attained around $40,000,000, the output has aggregated but 1,835,353 cubic yards out of the 124,615,000 cubic yards still to be dug or moved or placed. The excavation has thus far been in the upper material only. The submerged rock, the refractory clays, the sliding clays, these are virtually unessayed. And dry excavation is but one item—the preliminary. The dredging and the huge concrete structures are additional.

Truly much awaits the contractor.

At the rate of the past three years' record the digging and placing of material alone would consume two centuries. And its cost?

But the contractor is bidden to complete the waterway in eight years, and the money actually remaining assignable to its construction and to his travail and trial, pains and profits, is the sum of $42,000,000!

" American ingenuity is not dead! " The circular comforts and encourages the public. Alas! The patrimony is gone beyond the power of ingenuity however willing or gifted, to recall. The talents of experienced contractors, fertile in ways and means, and schooled in putting moneys where they tell and carry from beginning to successful end are called too late to redeem the dissipations and the mistakes. Our national enterprise has been already blundered and squandered to this impoverishment. There is left nowhere nearly enough for any combined devisings of groups of brains to rescue and construct this canal within the provisions of existing law.

But perhaps the sum can be increased from slicing and retrenchments elsewhere? The prospective bidder searches anew. Can the 20% fund be cut?

There is in every undertaking great and small a reserve held sacred against the evil days,—the accidental, the incidental, the sacrificial, " extra works or dams or reservoirs," refractory developments of under-estimated excavations, etc. Under the French incidental and excess expenditures ran very high, much above the construction work itself. Under the American management, contingencies and accessories have been likewise excessive. Administration and engineering are ordinarily figured at 5% each. Administration alone, this year, is at the rate of over 10%. When therefore administration, engineering and contingencies are grouped together to be covered by a 20% reserve it is plain that there is no margin to be impressed from this quarter.

Between the 145 millions of the Spooner appropriation and the nearly 140 millions of the 85-foot estimate, there is an apparent margin of about five millions. Perhaps some or all of this can be enlisted. But the estimate departing from all precedents excluded allowances for sanitation and Zone Government. In the Senate testimony (page 1657) it was shown that at the most conservative reckoning these items estimated for a force of 20,000 men, must call for nine million dollars. Sanitation has been one of the costliest expenses thus far. When the contingent is increased to 60,000 and the swamps are being worked through this sum must be surely increased. The call this year is for over $2,000,000. What will it be for nine years?

Thus there is a huge deficit in sight here and no chance to transfer a slice of the sanitation and Zone Government allotment to waterway construction.

There are no other sources. Where then is the basic money required for the contract for the canal? It is non-existent under the law.

Contractors of standing, bankers, and sureties stop here.

The rest concerns the people only in reckoning with their stewards.

Suppose the cost committee ignoring the situation hand out a basic estimate of $80,000,000. Will the contract be legal? Will this Commission be permitted to again bind the Government to pay moneys known to be far in excess of that stipulated and sanctioned by law? Must not such a contract be first authorized by Congress?

Next, the contract seems a nominal one only. The contractor appears to be but a disguised agent. Is it in accord with statute that a Commission can hire employees or agents on a percentage basis?

Does this system prevail in the construction of public buildings, or river and harbor or irrigation improvements? No. The work of the great departments entrusted with the expenditure of public money is let for a definite price along precise and tested lines of safest procedure. It is extremely debatable if a so-called contractor would find himself with standing at court.

All these equivocal aspects are in the financial and legal situation. The personal phase is examined next.

He recognizes that in inviting bids at this late day it is not done because the officials have signally succeeded with their great task. Had progress been rapid, economical and satisfactory, there would have been no need for Congressional investigation, and no occasion now for a change and the introduction of other brains.

Public opinion has been strong and general that the Canal should be contracted. The chief motive impelling this universal demand was that a definite price might once for all be arranged and the waterway be guaranteed to completion within this sum. Thus and thus only could the people feel sure and the national treasury be safeguarded. This was the only real test and the supreme value of the contract system. Now this substitute is put forth.

What is the personal equation? He reviews it in relation to a little back history.

There have been contractors and contracts at Panama before. This last one harks back to the first which in all fundamentals, it but paraphrases. Couvreux and Hersent opened the lists at the Isthmus. They were the Suez builders, tried and successful, in whose much heralded "guarantees under forfeit" public confidence was propped and the great loan floated—the loan into whose sea of money the Canal enterprise like our own was launched.

The contract is dated March 12, 1881. Article 6 reads: "The execution of the work will be divided into two parts: The period of organization (which will last about two years) during which the delivery of the greater part of the material and the installations will be accomplished and the work attacked at many points so as to get an exact appreciation of costs to permit the establishment of unit prices. Second, the period of execution proper which is to be regulated by a special basic convention as to unit prices which shall state the cost of execution and definitely determine the relations between the company and Couvreux and Hersent."

Article 10 sets forth that for their services in the first period they are to get six per cent. of the cost reckoned by the terms of Article 7.

Article 11 defines the remuneration of the contractors for the second period. By Articles 8 and 9 provision is made for determining costs first directly between the company and the contractor, and in default of an amiable agreement, by a committee in which the neutral vote is to be cast by " an inspecteur-general of the Ponts and Chaussées de France," and in last resort by Ferdinand de Lesseps. Our arrangement allows no neutral arbiter while the chairman of the Commission is final dictator.

As remuneration for the second period, having plant and capital placed at their disposal substantially as now purposed, Couvreux and Hersent were to receive half of the difference between the contractor's cost and the basic estimated cost; the company was to get the other half. Further the staff of the company and that of the contractor without distinction were to get a fifth of the half accruing to the contractor. Our imitators omitted this last incentive in the rainbow premiums.

M. de Lesseps announced the acceptation by Couvreux and Hersent of an overhead limit of $102,400,000 for their prospective work—and this sum was allocated by the French company. Our Commission has not half so much by many millions to allot for its contract for a canal twice the size.

How did the first contract arrangement work out?

" At the end of December, 1882, Couvreux and Hersent renounced their contract." They had completed the first period—they had had enough. They found a mortality of first 7%, then 8½% per annum. They saw their staff decimated and they learned by first hand experience that their overhead limit " was not half sufficient and there could be no margin." So they withdrew. They gave much fine advice to the company, counseling that the work be divided among small contractors then clamoring at the crib without knowing what was in it. So the many small men came into the field next at Panama. Some did well, some poorly, some not at all. The company supplied plant and tools, houses, etc., and paid the labor rolls. In the effort after results, prices were advanced again and again. But this system of confusion and endless interference was defeated by the rain and disease and innate unfitness. The company cast it out and negotiating with six principal groups, inaugurated a new system of execution. Under it the Canal cost was made $190,653,800, which was some $88,000,000 more than the limit set for Couvreux and Hersent. Small wonder the latter felt moved to get from under!

Then came in 1887 the forced abandonment of the fatal sea-level scheme, the desperate turning to a high-level lock canal, the frenzied contract with Eiffel, as funds and credit flowed away, and the huge advances to gain the support of his reputation and his brain. Vast sums had to be reimbursed the six contracting groups for the loss of profits and the damages they had sustained by the change of plan.

Costly as all these incidents rendered the French contract prices, they were still less than the costs have been during the three years of our Commission directorate. It is to be observed further, that it was not the contractors, which brought to the French the greatest shame and the disaster.

During the interlude following the debâcle the railroad, still under the Canal direction, bonded the La Boca wharf for over three times its contract cost. This briefly was the story of the French. What has been the American record?

The scroll unrolls to the continuance of the illegal contracts in restraint of trade previously made by the Panama Railway with the Pacific Steamship lines. After the longest delay practicable in carrying out executive orders the contracts were canceled in the body, but their spirit is still kept and the constraint remains.

Next contracts were made for plant and supplies far exceeding the appropriations of Congress and pending special acts of grace, millions of dollars were held up and vouchers remained unaudited and unpaid for many months.

Again, supplies were contracted under cover of the railroad organization when the exhaustion of previous appropriations left the Canal fund depleted.

Then came the first effort to let an important outside contract for work. As it seems unfortunately to be in some features typical and illustrative, its procedure is detailed:

On May 22, 1905, specifications were sent out for dredging an inner harbor at Colon, where the Commission's engineers had been making surveys and borings for over a year. The following information was given to intending bidders:

Specifications, Clause 43:

> " No guaranty is given to the character of the material to be excavated. This material apparently consists of mud, sand, stiff clay, loose coral rock and indurated clay, all unknown in proportions."

This and a small map of Colon was absolutely all that was given to general contractors. It is plain that a contractor having the data collected by the Commission or by its favor would have the ruling vantage.

Contractors were told what they could do in Clause 34, which said:

> " Bidders are expected to satisfy themselves as to the nature of the work to be done, and it will be assumed that proposals are based upon a thorough understanding of its character. Intending bidders are urged to visit the localities of the work, and by personal inspection and inquiries, fully to inform themselves as to the present and probable future conditions."

One firm had been afforded special information. Report of the Isthmian Canal Commission, page 251.

The specifications further, excluded firms by not giving time to make independent surveys. Specifications were issued May 22, bids were receivable June 15. In other words twenty-four days were given to go to Colon, to make investigations for a bid upon dredging to 30, 35 and 40 ft, under unusual conditions in material that was not given under any but the vaguest terms, to make an engineer's report and to return with it, to make up prices and finally to hand them in at Washington. As the trip to Colon and back then took fourteen days, the representative of a company, not previously advised, assuming that he started on May 23 as soon as the specifications were delivered, would have had ten days to make his investigations of materials and quantities, which the Commission declared itself unable to furnish after 1½ years investigation.

Finally the quantities to be bid were not given. The contractors were requested to furnish a 20% bond on the amount bid, which was unknowable, because the total yardage to be dug was not given.

But the latent potentiality of this absence of quantities and proportions of earth, rock, clay, etc., was that the contract was most accessible to a bidder who had tested the relative quantities.

This inadvertence, however, caused so many protests that on June 7, 1905, one week before bids were opened, approximate quantities were given in a mimeographed supplement. Not till then was a formal and legal bid possible. So this amendment gave dredging companies, not in cognizance of the real relative quantities, one week to go to Colon, make up their figures and return. The matter ended in the rejection of all bids and the contract for dredging of an inner harbor for Cristobal deemed so pressing as to demand this unusual course was dropped and has not been revived.

Following it came the Markel contract so flagrant that it had to be cancelled. Its history is generally known.

Next were the lot of bonds illegally contracted and sold to fill the emptied coffers of the Panama Railway and when brought to publicity hastily bought back.

In sequence came the Pipe Line Concession. This portentous privilege was, without even the fiction of competition, by direct action of the Secretary of War, ceded to the Union Oil Company of California. There had been previous applications which were of record, but priority and equity were ignored.

The Secretary of War, in justifying to the Senate Committee the franchise, announced that others could secure similar concessions under the same terms. Surely no one could consider such a paralleling proposition seriously. There are certain privileges which, from their nature and quality, as well as from local conditions and topography, become natural monopolies. This the Secretary must have known is one of these.

One oil pipe line can be tolerated along the railway or within a certain distance of the canal property. Two lines with branches, tanks, etc., would be a nuisance, more than two would be a plague.

The license is called " revocable " many times. After citizens have spent hundreds of thousands on an installation, how revocable is it? It cost $10,000 to revoke the Markel contract which had not begun on an installation. The Union Oil Company writes March 24, 1906 (page 2700) regarding a proposition to declare its pipe line a common carrier.

> "This company is investing its capital in terminal facilities and a pipe line across the Isthmus to the extent of over half a million dollars."

What will the price of this revocation be? The Government surely cannot use its power of revocation as duress.

The Union Oil Pipe Line will stay. It will be profitable in too many directions to be lightly abrogated. Nor unless illegally operated could it be justly revoked.

It is stated that the permit of the Panama Republic was required. The Union Oil Company, which made its formal application thirteen months later than the first, was told this, none other until after the grant was bestowed, as the records show.

The Panama Republic may not give exclusive licenses over the United States Zone, but it can limit the number installed in various ways. It may designate localities for oil stations in its areas at Colon and Panama, where there is only room for one party. It may make designations, reservations, ordinances, harbor or other regulations feasible for only the first occupant in the field, etc. The United States Government, the Canal or Railway officers may do likewise, not only at the terminals, but all along the Canal and Railway. The Railway or the Government own the available sites near Colon for oil terminals. The Union Oil Company has been negotiating for the key property at Panama. Its installation is nearly if not quite finished.

The interview with the manager of the Company published as soon as he had the object of the quest, showed a full appreciation of the situation which the company had won in relation to the canal.

The principles underlying this oil situation at the Isthmus remain unchanged and what should be the public policy is unaltered.

a. If the Government itself builds the canal it would wisely own an oil pipe line plant so as to insure the cheapest supply and greatest convenience and greatest freedom from complications with private interests.

b. If the Government should divide the work into short sections and invite the competition of contractors, few or none can afford to make other or numerous receiving and distributing oil installations, so they will be at the mercy of the first line put in.

The control of the fuel factor is now practically surrendered by the Government and there is little to prevent those who control the fuel from deciding who shall get the contracts.

c. If the canal work be divided among half a dozen contracts the objections cited still apply. The fact persists that possession of what amounts to a natural monopoly by reason of the Isthmian topography and general and local conditions may be exercised as a most effective lever to favor certain bidders or contractors against others.

d. A large single bidder or contractor would probably have to figure to buy out this installation, combine with its owners, or put in his own line.

e. By the terms of the " revocable " license the " said pipe line shall be constructed and in operation on or before the 1st of August, 1906."

Suppose the Commission advertises for bids to supply, say, 50,000 barrels of fuel-oil at Obispo, January 1st, who is going to tender? Anyone but the Union Oil Company? Surely not. No one else can compete.

The Canal fuel business must practically be in the hands of the Union Oil Company, and all that this control implies. The theory that capital will rush to gridiron the Zone when fuel is wanted from time to time, is, in a business sense, futile and untenable.

Next in sequence came the Chinese Labor Contract. Its terms have not been made public but in principle it is one of the most deprecable and impolitic and unnecessary measures of our history.

With this unrolling of the scroll and the search light thrown upon the personal equation, the prospective contractor comes to the last, the omnibus contract for the execution of the whole canal.

The Lock Canal at Panama.

It is very briefly reveiwed. The instructions preclude the establishment of a definite program of execution with reference to a definite plan for after three years there is no definite plan. Yet the canal design has the most intimate bearing on the character of the plant, the progress of work and the ultimate costs.

The invitation specifies an 85 foot summit level which compels locks in vicious flight or a limitation of canal capacity.

Any proposal which remedies this fundamental error is " informal," and subject to rejection.

Article I. Nothing is " fixed," plan or price, time or plant, or program of work.

Article II. $5,000,000 is inadequate capital. The force to be taken over is vast—the present unit costs are so high that a " contractor " must be charged a tremendous debit balance before he could possibly revolutionize the work, even were he to be let, by establishing better methods of execution or getting the plant he must control to succeed. It is only about 100 days' margin for payrolls, minor plants, and an ocean of accounts and the Commission's audit will be a drastic debate with inevitable delays in payment such as have prevailed very extensively in the past. Besides, he may be saddled with the expenditure of a million or two for plant on the Isthmus to *manufacture* cement and explosives. The Commission furnish plant for *construction* only.

Article III. *Bonds*. The contractor and his sureties are held liable " without notice " the form even of which is not prescribed. They may wake up to find dozens of suppressed or " failed " notices which may operate to infinite harm.

As changes of plan are inevitable there will be surely multitudinous variations of liability and surety companies are to abdicate the determination of their liability to the Commission, with or without notice.

Article IV. The officials of the Panama Railroad are carefully preserved the privilege of participation in this deal. It were a departure surely if the hospitality of the national board were at this far day withdrawn from them.

FORM OF CONTRACT.

The contracting group in principle is merely an agent or employee who is lured into a hope that he will get a percentage for the use of his $5,000,000 and his brains.

$5,000,000 is worth 2% or $100,000 to the Government. The credit will cost the group $250,000 per annum—bankers' interest or participation. Suppose the contracting group gets 10% of a $10,000,000 turn over per annum. It has against this $1,000,000 of percentage money the bankers' $250,000, its own expenses $500,000, and say $250,000 for the members. This is not wildly tempting with $500,000,000 of straight healthy contract work in sight in New York State alone.

Article III. *Plant.* The Commission hand the contractor over their plant —the plant which at its highest output achieves 289,000 cubic yards per month.

The men operating these machines were picked from the labor organization, whose numbers embrace practically all the skilled operatives in the United States. They are competent and faithful and are paid nearly one hundred per cent. more than men at home. It is reasonable, therefore, to believe that the force has done its best and that the output per machine is close upon all that can be expected during the rainy season.

Now because the Commission has indulged itself in plants of certain types, these are to be loaded upon the contractor. No new methods are devised, no better system proposed. The proposition is but more units of the same kind to operate under the same conditions at the same cost and more men to coöperate with them. Indeed lest another system should be introduced and labor be superseded, it is expressly stipulated that no man on the gold roll now engaged by the Commission shall be relieved or dismissed, without the express permission of the chief engineer. It is asserted that the contractors' organization is sought, but the entire Commission force are saddled on the contractor, and he must take over the Chinese also to the privileged quota of 15,000, and any and all other contingents that the Commission may have arranged for. He must either employ another vast staff, thus compounding the labor rolls, or he must take this force which they have seemingly failed to effectively organize since they call him in.

By labor compulsions and the enforced use of the plants which the Commission possesses and is to supply, the contractor is so bound and nailed, that the Canal's one chance for rescue and salvation is largely forfeited.

A contractor possesses no magic to alter the nature of a tool. Neither can he exorcise the rain and the tremendous handicaps and impediments which its long season imposes. If therefore the self-same system and the identical plant are to be handed over, what difference in relative records is possible? It is absurd to look for anything, but the most meager incidental improvement. Unless the contractor is free to devise his own system, and design and order and control his chosen plant, how is he to be responsible for achievements? He is precluded from doing just the things on which his past success has rested. He cannot choose the makers of the mechanisms he must use; these will be designed for him, and let out perhaps to some bidder who may be inexperienced and slow and cheap. He must take what is provided. He has no power of requisition or design. Cranes there are reported already which would not take a curve, and locomotives which could not be fired, dredges that will not touch bottom, hoppers that can not be loaded with the too light silt. The Commission has in hand an ordering now of still other machines for other offices, so it is evident that the dictation of means and methods remains as of old.

The contractor remembers that the failure of some dredging plant selected and supplied by the old French company to one of its main contracting groups, bankrupted it. Two of the six partners died and the other four were ruined—though they were of those who got out the most cubic mass and made the best progress.

If there was any object whatever in calling in contractors, it was that other men unshackled of commitments and unhostaged to past mistakes might with free minds and hands devise other ways and means which would cut costs down to some approximation of the estimates and give the Canal one chance at least for its life. But the saving of the personal face of things and the perpetuation of the existing order are ends to which the waterway and the Treasury are sacrificed.

Next, raw materials are to be furnished the contractor at the Isthmus; he is precluded from treating, shaping and finishing them so far as possible in the United States. He must do all this at Panama. On the other hand if the Commission prepares the " raw material " in the States for the contractor, what a golden chance for graft! How likely is the cost of " raw material " to run high to the Government, and what chances for dispute lie in this direction!

Oil.—Prospective bidders for this contract will do well to see the Union Oil Company.

One is at this stage full of queries. If the contractor wants to employ a certain method or special plant, will the Commission give him free what he wants, or will it restrict his designs and defeat his plans? Will it honor his requisition for major plant or must he take only what it turns over as all-sufficing? Where is the limit? If it does not give him what he wants, how can he be held to the contract? These questions relate likewise to quarters, warehouses, buildings, etc. Will the Commission bury the dead and repatriate the invalid?

What are the regular published rates of the Panama Railway? Are they guaranteed against rise? This delectable organization has already raised freight rates upon a supply house after pledging a certain price. It is noted that the Commission undertakes to supply free water to *machines* but not to *men*. It does not guarantee the potability or purity of the water. Suppose an epidemic of typhoid or cholera traceable to the water breaks up the contractor's labor organization, will he get damages?

Suppose there be a riot of malaria and yellow fever because of the inadequacy of the sanitation—has the contractor any recourse? Can he help himself? What is "cost plus the usual handling charges?" Vagueness begets disputes. The contractor has the mess house privilege if he wants it. If *he* runs it and makes a profit it is charged to his percentage; if a loss he is recouped. Suppose he makes 50 cents per week per man—a reasonable profit as any one must allow; 50,000 men gives $25,000 per week or $1,300,000 per annum. This is debited to him for nine years say $11,700,000.

Since he can never complete the 85 foot scheme in the time or for the amount appropriated, is he likely to owe the Government all the mess profits for his reward?

But he is amiably left a way out. It is allowed that he pass the mess to a third party who is not subject to debit. The third party cleans up the profit and shares what he likes of his own. Mr. Markel had better move back.

The Commission is to maintain the plant. This is a fertile field sowed with dragon's teeth. A vital machine breaks, for instance. The contractor notifies the Commission. He wants a new one and cannot get it. The repairs proceed with exasperating slowness and inefficiency. The contractor loses thousands. What is his redress? Such cases will recur not occasionally but continuously.

Article IV. Where does the contractor come in when "engineering" by changes upsets his well-ordered plans. Here is a hive of stinging bees, since the "engineering" is in chaos yet. The damage bills entered after the French changes of design will give luminous heralds.

Article VI. Is there any limit to what the contractor may pay his staff? May he have a dozen McCurdy salaries or may the government audit lower the wage of his staff to extinguishment? Where is the line to be drawn and how?

To perform its tasks the Commission will have a permanent force of clerks, weeding engineers, mechanics, etc.,—thousands and thousands of men. Will there be no conflict along labor interests?

It is contemplated that the contractor may parcel out work to sub-contractors so the Cost Committee will be asked and inferentially must provide a reasonable margin of profit to the clientele of followers. The contractor's percentage need be bidden but small if he has a sufficient interest covered in the sub-contractor's profits.

SUPPLEMENT.

He compares the original estimates of the Commission, finds that the quantities and classification have been changed and using the old unit prices the canal cost has increased as follows:

Colon Section	$173,250
Mindi do.	679,000
Lake do.	2,354,000
Total	$3,206,250

Besides, the channel seaward from La Boca has been deepened five feet and the quantities increased by 3,198,000 cubic yards. If this extra quantity is all " soft " it adds $579,000; if there are many more hundreds of thousands of cubic yards of rock as he would naturally expect, the deepening will add a couple of millions more. Apparently then the changes incorporated since Congress adjourned will mount to five or six millions beyond what was then estimated. There is the corresponding increase in work to do and only the same $42,000,000 in sight for all.

He sees that it is within the possible that the locks shall be lengthened to 1000 feet, another great augmentation of cost and a corresponding increase in contract execution.

Next a flight of two locks may be substituted at Gatun each with a lift of 42½ feet—this by-way of concession to the overshort Gatun Hill. He realizes that the lockage capacity of the Canal will be diminished enormously because it will take 25% more water to lock a vessel across the Isthmus. The 42½ foot locks will be yet more hazardous in construction, in contractor's trials, for maintenance, repair and navigation, so the risks endanger yet further his capital and his profits.

He notes that " the Sosa locks are to be in flight of two with a lift of 27½ feet each." Two such lifts will not attain the level of a fifty-five foot lake at any stage of low tide. At dead low tide the lift of the seaward lock must be 9.5 feet more, a total of 37 feet. It is a little curious to build a canal with over 40 feet of water everywhere except at the Pacific entrance lock, allowing it, at low tide, but 30 feet.

It is not necessary to analyze further. One wonders at the end what is the worth of a $3,000,000 bond on such a contract. Is it likely that the Government ever could or would collect a dollar on default? And what group of disinterested bondsmen or bonding companies will guarantee its fulfillment? The writer believes that reliable Sureties will look beyond the prospect of premiums and the custody of a cash covering fund of no matter how many millions to the technical, moral and national aspect and will decline.

The contract is no contract--there is in it no equity, no justice. It is a speculation for plungers. A committee of three Government engineers are pitted continuously against a contractor's committee of two engineers. At stake are the contractors' capital, its interest, his profits and his bond. In dispute there is no impartial arbiter. The chief engineer and chairman, the two parties most adversely concerned and interested are his court of last appeal. Being denied all basis of equality and safety, the contractor is in the very first plain right of self-defense forced to scheme for the control of one man. This man won, the opportunities become so vast and so open that the temptation is compounded. With the inside track in the committee, costs can be anything and a small difference in unit prices will mean large slices in the appropriation.

On the one hand, therefore, the contract is tyrannous, oppressive and fundamentally unfair to the contractor; on the other it puts upon collusion and jobbery the premium of unbridled loot of the nation's treasury.

It is surely not credible that this is to be the solution for the Panama Canal.

It is well Grant goes to Chattanooga.

THE LOCK LADDER AT GATUN.

The question of safety in the Commission's arrangement of three locks in flight at Gatun has crystalized the greatest engineering conflict of the canal. The point of dispute is not here the conditions which attach to all locks. That there is an element of uncertainty inherent in every structure of whatever nature is indisputable. Were it possible to eliminate locks entirely at the Isthmus such a disposition would be in that one element vastly superior. But nature in her disparity of tides on the two oceans and in the height of her Culebra, denied this possibility. The sea-level even was a lock canal. The conflict has not therefore been drawn by isolated locks which the physical conditions permitted, but by the tier of three locks, one above the other, with a lake of eighty-five foot head at their summit,—that is by the Gatun lock flight.

The most reliable augury of the future is the past; the factor of chance at Panama is best estimated in relation to the actual records of other canals. There will be cited here only two, one of these the Soo having probably the most fortunate history of any, and another the Manchester, of average luck. It will be remarked as preliminary that there is not one existing canal which has escaped lock accidents.

The Minority report states of its best example, the Soo: " The gates of the Poe lock have been struck three times and injured more or less, but they continued to support the summit level." The Majority of the International Board point out that, on account of several conditions which cannot obtain at Panama, the Soo's record is no valid criterion. It writes also in regard to these three collisions " resulting in each case in dangerous damage to these gates." On the Manchester canal four graver accidents have occurred since it was opened for traffic ten years ago.

The Majority report summarizes in regard to mishaps, " several of these accidents were so serious that disastrous consequences were escaped by a narrow margin only. It is practically certain that if the locks upon which these accidents took place had been of the dimensions and *had controlled the great difference of level* contemplated for the locks of the Panama canal, not merely serious accidents, but disasters would have followed in perhaps all these cases throwing the whole canal out of operation for a period which cannot be estimated, and also wrecking the vessels in the path of the resulting flood, while the cost required to repair the damages is not within the limits of reasonable computation. " They continue:

" The three accidents at the St. Mary's Falls canal occurred within a period of nine years where there is only one lockage of about twenty feet. If six locks should be adopted in a plan for the Panama canal, each having a lift of thirty feet or more, as has been proposed in several projects, it would not be unreasonable, with an equal number of vessels, to look for six times the number of accidents in the same period of time, which would be at the rate of two per year. *If groups of locks should be arranged in flights*, as has also been proposed in some projects, the imminence of disastrous accidents would be greatly enhanced, as would be the amount of damage to the structures and to the vessels involved. Indeed it is highly probable that the grave disaster of a great ocean steamship breaking through those below might be realized. It is the unqualified judgment of the Board that the United States Government should not construct an interoceanic water way to accommodate the commerce of the world exposed to hazards of this sort.

These conditions become even more serious when it is contemplated that the canal is to be used for strategic purposes and therefore for the interoceanic transit of vessels of war of the United States navy. The difficulty of handling the ironclads in the most favorable circumstances is notorious, while in the operations required for raising them in one series of locks and for dropping them down in another series, the difficulty would *come so perilously near impracticability* that, in the opinion of the Board, no scheme involving it should be accepted."

Such a clear, precise and complete denunciation of a government measure by a body of specialists called from the leading nations to select the best elements for a canal, it would be hard to match in the annals of any profession.

But all this the Minority, Commission and Secretary of War receive in disdainful incredulity. They waive it aside. " The possibility that the ship will so completely wreck the first pair of gates as to continue its course to the second and seriously harm it is extremely small," they reply. It is not that they are foolhardy, they are just superior. Colonel Ernst voices the general attitude. " There are some people you know who are afraid to go up in an elevator."

The Majority has figured the mathematical frequency of lock accidents for Panama, taking the Soo as the basis, at two a year. On the Manchester the experience has been less fortunate, both as to number and seriousness, so that if the English canal serves as a basis, Panama's chances are materially lower. The Majority's casualty estimate considered intervals of time and number of locks alone. But there are several other elements which increase the hazard at Panama. The Soo and the Manchester are both in temperate zones where mind and body have their highest efficiency. At the Isthmus the vitality of men is reduced, alertness and initiative are at their lowest. Lock tenders, watchmen and pilots will suffer the same effect of climate as the employees of the Panama Railroad and canal. The capacity for rising to emergencies with quick accurate judgment and activity will be lessened to a point of inertia increasing the hazards.

Add further, in estimating the frequency of accidents, that a much larger and hence more weighty and less easily maneuvred class of ships will use the Panama canal than the steam barges, coasting vessels and small craft which largely use the Soo, the Manchester, the Kiel and other canals.

Accidents are therefore at the Isthmus certain and inevitable. When the casualty shall befall and how and where cannot be predicted. But just as of the ships that go down to the sea, a certain per cent. must be lost, so of the ships that pass at Panama some must mistake and misbehave and the trouble be wrought.

It becomes evident therefore that if on the Isthmus casualties are to be held to even the average of the small waterways, very extra precautions must be taken and the most perfect and most thoroughly tested safety appliances must be provided. With accidents certain and inevitable and natural drawbacks so multiplied, there must be no further handicapping that is at all avoidable.

The nature of a lock accident and its results are more readily understood in the concrete than the abstract. Local accounts are inserted of the two latest canal mishaps, both very recent. The first befell on the Welland, the second on the Manchester.

" STEAMER WRECKS CANAL LOCKS."

> " Ogdensburg, July 23, 1906.—Navigation through the Welland canal will be stopped for several days as the result of the steamer Nipigon of Ogdensburg carrying away five gates. The cause of the steamer running amuck in the locks is attributed to the engineer making a mistake in the bells, giving his engine full steam ahead instead of backing as he was signaled to do."

Five gates carried away before the steamer could be controlled—five gates and the steamer of the small lake type!

The following article appeared in the Manchester *Guardian* of June 22, 1906:

> " Shortly after eight o'clock last evening a serious accident occurred at the Irlam docks of the Manchester Ship Canal—the most serious

accident that has occurred since the canal was opened. The steamer Cassia, a vessel of about 700 tons, bound for Manchester with a cargo of 1,438 tons of sulphur ore, reached the Irlam locks in charge of a ship canal pilot, and for some reason that has not yet been given made for the large lock No. 65 that was being filled for a steamer outward bound, instead of the smaller lock No. 45, which was in readiness to receive her. The vessel collided with the lock, and although she had very little way on her the impact carried away one of the gates. This set free the water in the locks, and the weight of water above on the other gates caused them to give way. The result was that the water in the higher reach of the canal poured through the lock.

" The seriousness of the accident is not the damage done to the lock itself, but its effect upon the height of the water in the reach of the canal above the lock. The carrying away of the gates gave the water a free passage and lowered its level above the lock by sixteen feet. Mr. Hunter, the chief engineer of the canal, and a large staff of officials, went from Manchester to Irlam. Our representative had a brief conversation with one of them, who stated that traffic between Manchester and Irlam must be suspended for at least some days. The depth of the water between Irlam and Barton had been reduced so much that it was impossible for large vessels to pass. ' Everything possible,' he said, ' is being done to restore traffic at the earliest possible moment, but there is no ignoring the fact that it is one of the most serious accidents that has happened.'

" The Cassia had a narrow escape. There was eight or nine feet of water in the lock. It struck the vessel like a waterfall, and it was only by the prompt action of Captain Olgan that she was saved. In an interview last night the Captain said that this was the first time that he had been up the ship canal, and he had left the entire control of the vessel to the pilot. He thought it was almost miraculous that the boat was saved. ' We were practically stopped,' he added, ' when the boat struck the gate, but the gate was carried away and the vessel meeting the full force of the water coming out of the lock was tossed like a cork. Fortunately I was able to keep her bow on. Had she been struck broadside on she would have been wrecked. A large vessel was coming from Manchester to enter the same lock, but luckily she was some distance off.' The rush of the water was felt for a considerable distance, and at the coal tips a quarter of a mile away a ship was torn from her moorings.

" A visit to the lock early this morning establishes the fact (writes a representative of the Manchester *Guardian*) that for a week at least all traffic on the canal must be at a standstill. In the Irlam lock the water is sixteen feet below the normal level; the muddy bottom is in many places exposed; and an abominable stench fills the air; gangs of men are busy preparing for the work of repair, and up till a late hour Mr. J. K. Bythell and other officials of the Ship Canal Company were directing affairs. Everybody able to give information was pledged to secrecy, but certain facts were obtainable. When the Cassia entered the lock, Manchester-bound, she was traveling at normal speed for such a waterway, but from some unexplained cause maintained her headway, and ere the gates behind her could be closed, she had crashed into the gates in front. 'The force of the impact,' said one who was near, 'caused a terrific noise, and this din was repeated shortly after, for the officials on the spot seeing what had happened, hastened the closing of the hind gates to prevent the inevitable onrush of water. Quickly as the machinery worked it failed to achieve the purpose desired. The water in the lock, finding an open course to Liverpool the moment the collision occurred, rushed onward in a seething current, and the volume of water on the Manchester side of the lock forced its way through the hinder gates, defying machinery and every restraint. Very soon the seriousness of the disaster was apparent to all. The Cassia cleared the gates she had destroyed, but landed on the lock sill, and close by she now remains. The damage to her bow is slight. Coming from Manchester was another steamer, and soon its plight was perilous. The water in the lock is at ordinary times sixteen feet above the level of the water on the Liverpool side of the damaged gates. Very soon the sixteen feet were reduced to a dozen, then the muddy bottom of the canal became visible, and the steamer was high and dry. For a time the Captain expected his vessel to turn turtle, and he was powerless to do anything. Fortunately she swung across the canal, and as the lock emptied the vessel was propped up to prevent her taking too great a list. For some days she must remain for all practical purposes a steamship on dry land, shored up to keep her on even keel.

"The stretch of canal affected by the disaster is from two to three miles long. Fortunately the tremendous onrush of water from the higher to the lower level caused no further calamity.

"The Ship Canal Company propose issuing to-day an official statement as to the causes of the disaster. Meanwhile gangs of men, with every possible appliance for quick repair, are being organized for the

> rectification of the damage. It is intended to work night and day, and it is hoped that in about a week the canal will be again open for traffic."

With such showing and behavior as are recorded in these two accidents just a month apart on the Welland and Manchester, it is in order to examine what occurrences similar to either one would entail at Panama with locks not single and isolated as were the latter, but in a flight of three.

First we consider what safety devices, not in use on these two canals, are proposed by the Minority for Panama. The first safeguard is to be a precaution, not an appliance. Ships are to be forbidden entering locks under their own steam, or rather the Minority maintain that this provision is to be incorporated, but the Commission state otherwise. The two bodies contradict each other and report the most glaring inconsistencies as to how the locks are to be safeguarded. But accepting it that this additional caution is to be observed, how does it operate?

Colonel Ernst: " The boat is pushed forward 80 feet."

Senator Kittredge: " How pushed forward? "

Colonel Ernst: " By capstans or whatever power is used for moving the boat. She is moved forward by her own power or by some other power, probably by capstans."

We pause over this expert decision and ponder. Pushing or pulling the ship along by capstans! And the canal capacity this specialist rates at twenty-six lockages a day! To pull and control through three conjoining locks, a dead weight of some forty thousand tons will take an interesting system of bow lines and stern lines and breast lines along the staircase. For vessels of large size this looks a bit labored, and certainly to worry through one vessel would consume no small part of a day.

But another expert denies all this. It is his system which is to obtain. Page 1941:

Senator Kittredge: " How would you push it ahead? Would you use a windlass or what? "

Mr. Stearns: " Generally it would be done by a tug behind it."

It will certainly be highly entertaining to see a tug, by " pushing behind," get a ship through this flight of three locks. Does anyone recall having been down at the New York waterfront watching an ocean liner make her berth? Four to six tugs were puffing and hauling to pull her into position and they had ample room to maneuver withal. Now a Cunarder of 788 feet in a lock of 820 feet or even 900 feet usable length, would not leave a very lavish margin for one tug to disport herself in. Imagine this solitary tug in the abbreviated, constricted lock shoving against an ocean liner! Or picture one of our ten million dollar battle ships, in alliance with the "Dreadnaught," in emergency hurrying through the canal and an estimable tug behind each, desperately pushing it to destiny! Is not all this ingenuous? Does it not approximate a little the humorous? The "prohibition regulation," so far as it has been set forth by its advocates, cannot be considered seriously as a security measure.

Double gates are the first safety device proposed. These come within the realm of the practicable and merit an analysis. The design is briefly, for the nine hundred foot locks, that inside the end gates there shall be installed an inner gate so that there may be always two gates in front of a vessel and two behind her. It is apparent that this reduces the safeguarded available lock lengths to eight hundred and twenty feet and leaves but thirty-two feet of margin above existing vessels for the dimension increase of the future. An order is just reported pending for a steamer larger than the "Lusitania," so the thirty-two foot margin is jeopardized already. But, passing for the time the question of adequate lock length, what is to be said of the safety device itself?

It is unquestionably of hope, and it would seem at first sight to promise large value. But a closer consideration quite reduces this. The small steam barge Nipigon, on the Welland canal, found no difficulty in crashing through, not only two gates separated by 240 feet of water, but through five separate gates. Multiply the Nipigon's effect by the ratio of her tonnage to the Carmania's, for example, and the double gates become in an accident almost as futile as paper.

Should the lower gate, say, of the upper lock at Gatun be over-run before the upper gate is closed, it would release a head of water of twenty-eight and a half feet into the middle lock. Allow for example that the safety dam for the summit level could be set in five minutes. The theoretical velocity of water with a head of twenty-eight and a half feet is forty-three feet per second equal to a rate of thirty miles per hour. In the five minutes, or three hundred seconds, needed to get the safety dam set, a weight of over five hundred thousand tons, including the ship, will be precipitated on to the middle lock. The ship will become a swift gigantic catapult in the grasp of water. Reversed engines could avail nothing against this avalanche. In a few seconds the ship would strike the third set of gates, release another eighty-five thousand tons or one hundred thousand, get an accelerated speed, overwhelm the last set and dive in a maelstrom of hundreds of thousands of tons, rushing down the eighty-five foot stepped slope. Double gates or a summit safety-dam avail nothing against the inevitable consequences of such an accident.

The claim is made that a vessel will not be able to run through two gates eighty feet apart. This is mere rash bravado. A wrong signal, the parting of a cable, the time element for reversing great marine engines and getting the effect of the propellers and eighty feet will be covered and the ruin done.

The pier in the North River shorn off like a daisy head by a French liner a year or so back and the massive stone breakwater of Dover lately rammed by the Deutschland, both cases when the ships were moving at slow berthing speed, are object lessons of the tremendous momentum in 40,000 tons of moving steel.

While a safety gate eighty feet away might prevent an accident due to a slight miscalculation of distance and the ship's hitting the first gate when virtually stopped, it would be of practically no avail in the case of mistake in signals, which is the ordinary and most frequent occasion of accidents, which caused the Welland mishap and most of those at Manchester. A gate and eighty feet of margin will be a forlorn hope for safeguarding a large moving ship in the face of such a disaster as a break in these flights would precipitate.

The remaining methods aim only at checking the flow of water in event of the lake's breaking loose through the lock gates. The Minority's report mentioned for achieving these, two appliances,—first a safety dam, a device installed forty years ago on the St. Mary's Falls canal, then removed without having stood the test of any actual trial, and second, a movable wicket device now installed in the same location, but again not practically tested and proven in an actual case of necessity. These two proposals are therefore experimental only; they are not solutions. But at this point the Minority and the Commission all rest the case. Their final word on the subject is this: " The problem of working out a satisfactory device for this purpose in the deeper channel of the Panama canal is a difficult one, but no doubt is entertained that a solution can be made. For such appliances the sum of $2,000,000 is included in the estimate of cost."

Such a treatment of this most momentous problem, burdened with the very brunt of the canal's defense, is manifestly an open begging of the whole question. While not citing or recommending any known method which has visually demonstrated ability to control an emergency rush through a lock, and while offering no solution whatever themselves, they yet profess entire confidence in something's turning up. On this Micawber basis it would be criminal to rest a final assurance of the safety of a flight of locks holding at such stake life, property and the country's honor.

But it is not the purpose of these papers to condemn only but to rescue the canal from its present blight. Does any method exist that could be savingly applied here?

Unless a solution which has been tried in the balance and not found wanting exists for Panama conditions they are likely to go unprotected. For the safety dam device cannot be relied upon despite the $2,000,000 appropriation,—$1,000,000 for Gatun, $1,000,000 for Pedro Miguel, and nothing whatever for Lake " Sosa," eight square miles in area and fifty-five feet deep.

Further, these safety dams "to be discovered " and about which no doubt is entertained, although on no canal in the world, could their proposers succeed in illustrating them, relate only to the summit level and to two locks out of six.

Mr. Stearns: " The inner gates or double gates, that you refer to, were placed only on the summit level . . . let me take first the two lower locks where there are no double gates."

The flight of two locks at Sosa and the lower two locks at Gatun are to go without even this hazy and debatable precaution. Is it fancied that the gates at Sosa, holding up a maximum sixty-five foot head, will remain immune from danger?

Leaving now the deplorable treatment of this vital feature we survey the possible methods of control for the lock tier. From the water surface to the lock bottom is about seventy feet, their gate width is ninety-five feet, behind is a lake eighty-five feet deep with an area of one hundred and ten square miles. No floating caisson gate or vertical leaf or needle gate could combat or be closed against the rush of water at 30 miles per hour. It is therefore apparent that one method alone offers any assurance whatever of success—the bear-trap-dam system. Its principle appears practicable. Yet mark what this device would mean as the safeguard to the summit lake in case of an accident to the upper gates of the Gatun flight.

A bear-trap-dam requires a certain bottom length. To install one here requires at least two hundred and fifty feet. A safety dam ought to be itself in the safest position. The safest position is not in the lock—a broken gate or a vessel may be directly over it. The position just above the upper gate is hazardous, for right here a ship torn from moorings would most likely jam. The safest position, *per se*, is about a ship's length clear of the upper lock—one thousand feet (or, if you please, nine hundred feet). This brings the safety dam just where a ship, waiting to lock, must moor to be well clear of the powerful suction currents of the sluices of the upper lock. But the safest place for the pivot of the great horizontal leaf is here, one thousand two hundred and fifty feet from the open gate. Already this upper " official " gate is beyond the brink of the rock in Gatun hill so far that the end of the lock chamber at the bottom is forty feet above the rock-line.

The data available to the public at this point shows that from the pivot axis of the leaf to the rock-line would be about eighty-six feet. The dam, therefore, must be designed to turn on tower-like abutments eighty-six feet high, perilously close to the limit of pneumatic work. The device must rest when not in use upon a two hundred and fifty foot bed whose end supports are seventy to eighty-six feet high above the rock, unless it be impossibly floated on soft clays like the approach pier, or poised on piles.

Not only this, but besides, there must be either two such bear-trap-dams, as the locks are in pairs, one each side of their single central approach pier, to be built, as the testimony shows, afloat on clay, in eighty-five feet of water, " of wooden cribs capped with concrete," or the dam must have one leaf two hundred feet wide, between an extension of the lock walls. The official drawings give no such extension of the lock walls. The gate space is shown overhanging the brink of the Gatun cliff. It would be interesting to see the original lock drawing which Mr. Noble says he himself prepared, free from the blemish of a copyist's " mistake," giving locks with nine hundred feet of usable length inside the safety gates and showing the " safety dam " lakeward from the upper lock. Did it have one?

The closest that the " safety dam " could be placed is three hundred feet from the open upper gate, a very risky position which allows a gate clearance of but fifty feet.

Surely such conditions must force the flight bodily northward 300 to 1,250 feet and must lengthen the chamber for the whole " flight " mechanism. The chief engineer hastily certified to nature's favor for a three-lock flight, saying that he had then one hundred and ten borings on the exact site, which allowed not only 3,136 feet, but in one place 3,800 feet—enough for three locks each 1,150 feet. Did he reckon on a safety dam and the bed and space it must occupy? Such length as 3,800 feet was only found by advancing into the Chagres marshes north of the Gatun ridge. When a safety dam of the bear-trap type is incorporated, the lower lock will be perforce clear of the hill and all in the marsh. This is his " ideal site! " As the profile will clearly show, such a readjusting of the locks must vastly affect the whole design and make the amount of concrete to be placed and the cost simply stupendous. But every thing must be sacrificed to retain the three lock flight.

Perhaps their safety dam must be taken to be located midway of the upper lock, since the position of the upper gate chamber was fixed by the designer on the brow of the hill and the official plate shows nothing lakeward of the lock save the clay-floated approach pier. But this is manifestly a position unsafe for defense from vessels plunging from the lake level into the lock. For not only is the vessel, which may over-run a gate, in danger herself of jamming in the lock as did the Cassia at Irlam on the Manchester, but the currents induced by the disaster will assuredly tear craft from moorings along the approach and bear them to a ruin which would be most apt to prevent the working of the safety dam if it be placed inside the lock. The only safe place for the safety dam is well clear of the lock. If then a safety dam is to be installed commensurate with the situation and not of a perfunctory character, the three lock flight chamber should be at least for the Minority's scheme, a ship's length, 900 feet, plus 250 feet, the dam bed, plus 3,136 feet, equalling 4,286 feet. The Chief Engineer says he has " 3,800 feet, enough for locks 1,150 feet long." Well, for the abridged locks totaling 3,138 feet the site is 486 feet short and for locks of 1,000 feet minimum usable dimensions a fifth of a mile too small—even after the excursion into the Chagres swamp. The site is short, the locks are short, the estimate is millions short—the whole business is a short-sighted piece of deliberate folly. The rock core of the Gatun hill is wide enough for one lock and no more with all the paraphernalia of rightly founded approaches and safety devices.

From the above analysis the conclusion follows that the lock gates are not to be protected by prohibiting self-propulsion to vessels and the safety gates and dams are aids of no sure protection. What now of the lock-ladder at Gatun when the inexorable mathematics of mishap bring a steamer crashing through the gates? The conclusion is beyond challenge.

At Manchester in the last accident it was a small vessel with but 1,500 tons of cargo that wrecked two gates. This vessel landed on the sill and the short level above was quickly emptied. What will be the commensurate consequences of a vessel with 40,000 or 50,000 tons going through an upper gate of the Gatun flight from the great lake? There is no room for a safe safety dam.

Nothing else can transpire than that the ship will be seized by the flood, millions of pounds of steel gates and hundreds of millions of tons of water will hurdle down through the lower gates, tear everything to pieces—bury the flight-wreckage in a fathomless gorge in the marshes, and sweep its devastating way to the sea.

The deep concrete-founded locks must inevitably be eroded by the torrent flowing through and then around. The huge Gatun dam itself would be in almost inescapable peril, because the locks are an integral part of it. Every vessel in the waiting basin and every building and structure between Gatun and the sea in its path would be swept to utter annihilation.

The damage to the canal and locks could not be repaired for years. To refill Gatun lake would consume nearly a year of itself. The adoption of the lock flight arrangement, which puts so fearful a premium upon an accident, cannot be characterized as other than a most colossal and disastrous mistake.

What can be done to remedy the situation? The analysis of all safety measures but brings one back to the living fact—the lock flight cannot be safeguarded, its perils are inevitable. It must go; in that direction alone lies safety. With one separate single Gatun lock of but twenty-nine feet lift the efficiency of the safety gate system can be much more than doubled by inserting an intermediate gate midway down the lock. To any vessel less than 600 feet long there would be on entering the far greater safety of having not eighty but at least 400 feet of water to be over-run after breaking one gate, before reaching the next gate on the same level. On leaving the lock so divided, two separate gates would sustain the summit level. While passing in a contrary direction the reverse would be true, there will be two gates safe-guarding the rear. Besides there is ample room for a safe safety-summit dam, and rock founded approach piers.

In the case of a vessel larger than six hundred feet there is still one hundred feet greater leeway allowed by the single full separated lock proposed, than under the Minority's system.

Considering the event of a ship's crashing through all gates and releasing the summit lake, though it is far less likely under the separate single-lock disposition, still it is possible. But the damage would be confined there largely to the lock gates themselves. There is the further security element that there is a far greater surety of controlling it by the safety dam systems.

But even with the low head, though an accident is far less likely, the eventuality must nevertheless be faced, of a gate's being knocked out some time and the upper level's getting beyond control. It is in the absence of serious consequences therefrom, in addition to the smaller likelihood of the event, that the final superiority of the isolated lock type rests.

Under the Minority's design a torrent would tear down into the canal itself and the ship's waiting basin, while the thirty-foot head escaping in this separated four lock canal would be caught, and its shock dissipated and absorbed not in the channel, but in the broad lake below. The low slopes on its borders would permit an immense volume of water to be added without a great rise of level. In addition to this lake, absorbing and neutralizing the shock, the row of ample sluices especially designed in the barrage to discharge any excess flood, would prevent undue rise. The consequences from a breaking loose of the upper level, thus guarded against, would be confined almost entirely to the damaged gate and things afloat.

It is on these most fundamental grounds that the President or Congress should call for the abandonment of the three locks in flight at Gatun and the substitution on that site of one lock to lead from a lower lake to the summit level. The writer's project made on this principle of isolated locks and low summit level incorporates not six locks but four locks. The danger here again is therefore from this elimination of two locks reduced one-third. The only efficient solution giving a safe plan for the canal is this low head and isolated four lock system.

THE MINDI LOCATION.

It has been pointed out that the way to make the Gatun lock ladder safe, is to lower the level of water in the Summit lake and decrease the dam height and head; that the conjoining of locks into a flight multiplies lock dangers, while the principle of safety is to have each lock single and separate. This is not alone an ideal but also a practical solution, which is the valid and adequate reason for seeking its substitution for the present scheme.

There are certain considerations which must not be forgotten or fatefully neglected. If there is to be a single lock at Gatun and its corresponding dam, there are three localities to be considered where single locks as instruments of the lift over the main divide from the Atlantic may be placed: at Bohio; in the vicinity of Obispo; and at Mindi.

The position of the summit-making lock and dam must be determined by the transit capacity of the canal.

The canal must be able to lock through all the vessels which increasingly " shall be reasonably expected " to seek this gateway.

The lockage capacity is limited by the mean annual run-off tributary to the summit-level lake or reservoir. But this is not mathematically proportioned to the mean contribution, because the losses from flood wastage, percolation, infiltration, evaporation and gate leakage vary with each plan of canal.

The mean annual run-off is as follows: If the summit lock is at

Obispo (Gamboa)	3164 c.f.s.
Bohio	4798 c.f.s.
Gatun	8480 c.f.s.

When the demands of lockage, together with the losses from wastage (after reservoirs are full), percolation, leakage and evaporation in, for example, a summit level planned between Obispo and Pedro Miguel, reaches the 3164 c.f.s. of the mean annual run-off, the reservoir dams above Gamboa of whatsoever size they may be built cannot add anything to the transit capacity of the canal, because dams do not create rain and rain is here the one source of water supply. It has been mathematically demonstrated that the transit capacity afforded by the 8480 c.f.s. passing Gatun is over four times that given

by the 4798 c.f.s. of Bohio and many more times that of the 3164 c.f.s. available at Gamboa.

It has been accepted as certainly fundamental that the Isthmian Canal should be able to pass at least 50,000,000 tons per annum. This can be done only if the summit level begins at Mindi or Gatun, and it is idle blindness to propose sites at Bohio or at Obispo.

Accepting as the only worthy postulates, first that locks should not be placed in flight, and second that the canal built should be adequate to future growth, it is seen that it is impracticable to have more than two locks on the Atlantic side—one at Mindi and the other at Gatun. It never has been and it never will be practicable to make other dispositions.

No Commission, French or American, no advisory board or Congressional Committee or official has ever squarely faced these incontrovertible facts.

There cannot be more than two separated locks. If two locks are planned, one must be at Gatun and the other at Mindi. If there be but one lock on the Atlantic approach to Culebra, it must be at Gatun *or* at Mindi.

If at Gatun, a dam be made on which there is only a 29 foot head and but one separate lock, lifting from a lower lake at around 33.5 feet to the Gatun summit lake at 62.5, then the existing perils and perplexities incident to the gigantic dam and the flight of Atlantic locks are resolved. It is seen that the situation reduces itself to this—the creation of a lower lake at about 30 to 33.5 feet. The key to the whole Atlantic end of the canal becomes therefore the one location below Gatun for an impounding structure—Mindi.

At Mindi where the hills divide the Lower Chagres basin from Limon Bay, there is a gap, and where the Chagres River pierces the range there is a long, narrow valley. By closing these two small breaks with a low dyke and a sluice barrage, together less than a mile and a third long, this invaluable lake is impounded. The facility is truly surprising and the construction is almost the minimum possible, if this artificial lake is set at a low level. A glance at the map will show how very narrow are the two gaps. The easiness and safety of impounding so low a head of water gives certainty of the complete practicability and success of such a disposition. This lake at not more than 33.5 feet so simplifies and saves the whole eastern section of the canal, that only upon the discovery of some insuperable natural obstacle should it have been evaded. The transcendently vicious and evil combination of the great dam and the lock flight at Gatun should have turned the authorities to the most painstaking search for any attainable substitute. The inclusion of their two experiments and menaces would be justified only if they were the structures alone possible for securing a canal. No better way should have been passed till its last hope was quite exhausted.

The Lock Canal at Panama.

Consider what the creation of this lower Lake Chagres will effect! First and chiefest it will enable the Gatun monstrosity, under an 85 foot head, to be replaced by a low dam under a head of less than 30 feet, reducing the pressure to nearly one-third. The second greatest danger of the canal will be therein eliminated. Next, it will permit entrance to the upper Gatun Lake by a single separate lock. The canal's foremost danger and defect—the tier here of three locks—will be also eliminated. A solution which at a stroke wipes out these two engineering barbarities should, by a Commission seeking supremely the canal's good, naturally be welcomed with avidity.

Note further what this low-level Lake Chagres would secure. The distance from Mindi to Gatun constitutes the first three miles of the canal proper. Millions of cubic yards of indurated clay, as well as other refractory material, must be excavated here to get the channel down to 45 feet below sea-level, where it is located under the Commission's plan.

The Minority report does not provide for a waiting basin below the locks, and their waterway is inadequate for the reception of ships without one. The chief engineer points out this omission. He writes, January 26, 1906, p. 20:

> " I believe, however, that the construction of a large basin or inland harbor at or near Mindi, or at a convenient location which exists below the Gatun dam, such basin to be supplied with coaling and other proper outfitting facilities, will be found advisable; the material excavated in the construction of such a basin is to be used in the construction of the Gatun dam."

When a lake is inserted reaching from Mindi to Gatun it provides the ideal waiting basin and all this submerged indurated clay-rock excavation, the costliest digging on the whole canal becomes unnecessary and the very little dredging which remains to be done, is in the light upper silt, not in the lower indurated clays. The French channel is already cut through here to the depth of 20 feet. Add to this a lake depth of 33.5 and a channel 53.5 feet deep will exist practically all the way as soon as the low dykes are built. As these would require but six months' building time, the canal to Gatun (except as to the lock) could be available after this brief interval from the starting up of proper plants.

In addition to the great consideration of lessened submerged, indurated-clay-rock excavation the Mindi dyke impounding a low level Lake Chagres entered by the Canal's first lock here would also establish the site for the right Terminal City. From any Panama map it can be observed that to begin at Mindi makes transit in the canal three miles shorter than if Colon be the terminus. Assuredly captains of large ships will prefer to pass through the canal in day-light. It is admitted that under the Minority's design thirteen hours at least are consumed in traversing the waterway. Is it not better for this reason also to dispatch the ship from near Mindi rather than from Colon, three useless miles away?

Further the whole island on which Colon is built is a reeking swamp. The town superficially has an appearance of cleanliness, even of attractiveness, but the aspect is a lure and deception. The ramshackle frame houses of the town are set over the swamp on stilts. Sewage is thrown down into the marsh and goes in and out with the tides. Alligators swim from across Manzanillo Bay to make a daily meal of the refuse. The town is there only because it befitted the Panama Railroad. It does not fit the canal. A suggestion of what Colon becomes in the rainy season is given in the following dispatches of July 30, 1906:

> " RAINS A PERIL TO COLON. SANITARY WORK HINDERED AND STREETS RENDERED IMPASSABLE."
>
> " Colon, Monday. The month of July has witnessed a series of heavy rains on the Isthmus, which have hampered the work of the Americans for sanitation in Colon and made the streets of the town impassable quagmires. The conditions to-day are worse than ever before."
>
> And again: " A steamer from Colon arrives at the quarantine station in New Orleans—a plague ship with ninety per cent. of her complement stricken by the invisible armies of the jungle and morass. So virulent is the epidemic that the steamer is not permitted to come into port even after the fever is cured."

The *Outlook* of September 29 has a very laudatory article on the canal work, with praise for nearly everything on the Isthmus. It explains Colon's bad record by its natural handicaps. It writes:

> " Briefly, the situation is this: Probably no town in the world of its size presents so many difficult problems of sanitation. Swamp-built Colon is a natural hotbed of disease. The filth of years of foul living reeks from its mud. It is peopled almost wholly by ignorant negroes, many of them the rejected and worthless employees of the Commission. who in their huddled living disregard every rule of health. The chance that the selected plan for the Canal might cut off Colon and allow it to perish from very uselessness has passed. It must still remain the receiving and distributing station for the vast bulk of men and

supplies that are pouring into the Zone. Thus the health of the whole Isthmus depends upon the health of Colon."

The Mindi hills on the contrary constitute a high healthy site on which a new city could be started with right dwellings, right sewage system and every sanitary advantage from the beginning.

This disposition also makes available as no other arrangement whatsoever can the greatest and most perfect Atlantic harbor combination. The new city would have in front, an outer salt harbor on Limon Bay and behind, an inner fresh water harbor on Lake Chagres. Navies could ride in the lake absolutely protected by the encircling hills from the fierce " northers " which sweep Colon and compel every vessel in the harbor to take to sea. Dry-docks, depots and wharves could be located here, where not a wave would disturb their service. The fresh water would likewise kill the teredo and the barnacles, which collect on ship bottoms through a long ocean voyage.

Finally, there is an advantage, not technical, which must appeal to Americans nevertheless. Colon is a foreign city. While America has certain rights there, a foreign flag waves, a foreign council rules, foreign judges mete out sentence to our citizens. The new Mindi city would be upon American territory. The superb harbor, which Lake Chagres makes possible, would be our own. The inward position of Mindi would render it unreachable by hostile cannon so long as the forts at Limon and Manzanillo points—five miles seaward were not reduced. Behind Jaramillo Hill on Lake Chagres shipping or war vessels would be in the safest position that could almost be conceived.

Here then are a succession of supreme and incontestable advantages made by simply creating a low dyke and the sluice discharge arrangements and setting the first lock at Mindi. These advantages are ruthlessly and wantonly thrown away by the custodians of America's opportunity, who put over six miles between the foreign swamp-terminus Colon, and the dam and lock flight at Gatun. Surely at Mindi if anywhere at all on the Isthmus there is an imperious and impressive duty for thorough and exhaustive study and the most zealous effort to secure its betterments. What is to be said therefore of an ignoring of this location without a single boring and the collection of almost no official data whatsoever to present the truth. The President's order for data was precise.

We give the record of all that has been done by Board or Commission to gather information regarding the Mindi lock-and-dyke and the Chagres-gap sites.

During their week of visit to the Isthmus the Board alighted from their private train and glanced at the Mindi site from a point over half a mile distant. Subsequently three members set out in a launch from Gatun for the mouth of the Chagres River. But a blinding rain came on, a tropic rain which makes everything a blur. The launch passed swiftly down between the hills to the sea, around to Limon Bay and up the Chagres River debouchment and old canal to Gatun, then back again through the canal to the ship, never stopping. Allowing the launch a speed of six miles per hour, one may reckon that they allotted to the Mindi site six minutes. Could any engineering be less conscientious or profound? This inspection and the ordering of a meagre land reconnaissance, whose very favorable reports were absolutely neglected, sum up the investigation of one of the most pregnant and far-reaching opportunities on the Isthmus. No detailed examination was made nor even an instrumental survey, let alone a boring. With such superficiality regarding a crucial interest of this the greatest public work of all history, which a trusting nation believed was receiving the highest intelligence and devotion, the Mindi location with the full cognizance of the Secretary of War was passed over. It gave promise of changing the Panama canal from a thing of monstrous experiments and disasters to a national waterway safe for the commerce of a waiting world. But the evidence shows that these bodies of officials had gone to the Isthmus *pro forma* only and to cement pre-determination.

There is every good evidence that the sites at Mindi are not only practicable, but that they are the very best existing on the whole line for the low dam and the lock proposed.

It is a well known geological truth that a river deposits its large and coarse material upstream, and its finer and denser materials near the mouth. Thus at Gatun the indurated clay and alluvial strata are denser than at Bohio which is nearer the sources. At Mindi, still lower down stream, the deposit would be naturally more dense, more solid and more homogeneous still and hence better suited for foundations.

This geological warrant is borne out by all the collateral evidences. For instance, a short way seaward from Mindi the French excavated a dry dock in the ordinary material there, which was indurated clay. This clay is very dense, indeed quite impervious. In face of the fierce tropic weathering it still stands in a clean slope and is being used by the Commission.

The Mindi gap, by which the Chagres now partly discharges, is artificial; it was made by the French. A few feet below the surface this same indurated clay was encountered and it continued to the bottom of their seventy foot Mindi rock cutting. Now the dam-and-lock site contemplated lies between these two and other known points at all of which the material is shown to be most favorable—better than at Gatun. For a lock and sluice-barrage founded in easily reached solid indurated clay-rock, the location has every natural likelihood of proving the very best on the whole canal. Two weeks of surveying and boring by competent parties and records published would confirm this to the world. Will those whose lock dispositions are distrusted even by themselves, and some of whose perilous flights and dams they are already " re-arranging " elsewhere,—will they continue to stand under all it means to the country to thus systematically boycott the sites which would redeem their errors in the Atlantic end?

The engineer who made the reconnaissance and recorded his belief was not requested to go further. His official report and testimony was as follows:

> " On the west side of the canal the high ground is continuous from the Jarmillo Hill to the Chargres River. . . . From a personal examination I am quite sure that a point can be found in this vicinity where the distance across the Chagres Valley to an elevation of at least 50 feet is not more than 3,000 feet.
>
> " I think it more than probable that surveys would develop a possible crossing of a shorter length. On the east side of the diversion at Mindi the hills are simply isolated knolls for a distance of half a mile east from the diversion channel. From these there is a continuous ridge which is very much broken in elevation, but in which there is no point which has an elevation of less than about 40 feet.
>
> " It therefore seems possible that should such a project be contemplated, a dam might be built from the Jaramillo Hills across the canal, connecting the various hills as far as the east diversion opposite Mindi. From there, for a distance of half a mile, it is probable that a dam, having a base at an elevation of only five or six feet above the sea, would require construction for half the distance. In addition to this there would be a dam across the Chagres River of about 3,000 feet in length."

When it is recalled how safe on any foundations is such a low dam as must withstand only a 33.5 foot head, the likelihood of substrata, such as would preclude its construction at Mindi, is extremely remote since there is no old geologic river channel to be crossed.

Will the Commission then make or be ordered to make the official borings of Mindi and the lower Chagres? Let them retrieve their omission and neglect of duty and truthfully announce all the following:

A low impounding structure and lock at Mindi are easily and cheaply possible; if constructed they will enable the head on the Gatun Dam to be reduced from 85 to 29 feet; one isolated Gatun lock can then be substituted for the three in perilous tier; the most unique, commodious and splendid harbor can be constructed here with fresh water within and salt water without; a healthy site for a new city on American soil will be furnished; ten million dollars will be saved by the elimination of excavation due to diminishing the dam volume and cutting off the extra masonry needed to prop the lock flight; in six months after the provision of an adequate plant every swamp from Mindi to Tavernilla can be drowned under a saving lake conserving lives and money; this can be effected without interference with the service of the railway; it will make the Gatun dam and lock sites accessible to water communication and will bring at a stroke the construction of the Gatun dam within the economical and mechanical limit of dredging and pumping methods.

Can the Commission gather to their souls the needed courage? De Lesseps stood once at the parting of the ways!

THE GATUN DAM.

Of all the vexed features of this Panama proposal none save the lock flight has so drawn and centered fire as has the great Gatun dam. It roused in all engineers a query; in those familiar with the conditions, alarm. The doubt expressed has been as to whether the structure when built will have the stability requisite for its maintenance. So exclusively has this fear held the field of discussion, and so few specialists in execution have been heard from, that the primary question in regard to the dam has been apparently overlooked. Can it be built at all by the process announced by the Minority, and endorsed by the Commission, the Chief Engineer and the Secretary of War? The American Government has now been brought up against its construction, and it is surely time the situation were publicly analyzed.

In the report of the Minority the dam located in the Gatun gap is described.

It is given as 135 feet high, 7,700 feet long and 2,625 feet from down-stream to up-stream toe. Visualize this dam! Its crest is at the height of the Brooklyn Bridge above East River; its length extends from the Brooklyn abutment across the East River and across Manhattan Island and across the Hudson River to Jersey City and it is half a mile wide. The East and North Rivers correspond to the two channels around the Island in Gatun gap. Through these channels was discharged in 1879, the greatest known flood of the Chagres River, upwards of 233,700 cubic feet per second, (Bohio discharge plus 67%), or including the run-off from Obispo to Pedro Miguel roundly 240,000 c.f.s.

The Gatun Dam which is to enjoy such magnificent proportions is to be of the earth-and-rock-fill type, that is, at the upper and lower extremities, rock is to be dumped *pierre perdu* and the earth fill deposited between these winrows. The structure is to sustain a lake 85 feet in depth and 110 square miles in area. Its volume includes 21,200,000 cubic yards of earth and rock.

The rock for this monstrous construction, though costly of distribution by train is attainable. The ridge-like toes can be built despite the manifold difficulties that attach to selecting from the saturated and slackening, sliding clays and volcanic mélange of Culebra, millions of tons of firm clean non-disintegrating stone. But the great body of the lordly cenotaph is another matter.

The Gatun Dam.

The official description reads as follows: " The lower part of the dam up to elevation 50, or even to elevation 80, is to be made from material dredged from the canal between the Gatun locks and Limon Bay, pumped by a suction dredge into the dam." (Board Report, page 69) " and the quantity to be so dealt with totals 17,940,000 cubic yards," about 27,000,000 tons.

Senator Knox confirms the process in his speech advocating the lock type in the Senate·

" It is proposed to construct this Gatun dam entirely by the hydraulic or water-sluicing process, the material being taken largely from the prism of the canal between the dam and Limon Bay, being largely clay with some fine sand" (page 8980). And again page 8984:

" This point is emphasized in consideration of the proposed method of construction, namely, that this earth is not to be put in loosely, but to be put in by sluicing with water."

The testimony of Mr. Stearns before the Senate Committee, when being examined as to the process, further corroborates this specified method. The material is to be pumped with dredges, " such as are in use at Galveston." (S. R., page 1901.) These are the only machines of this type in the United States, and one is the largest of its order in the world. They are engaged in the work of raising the city. It may surely be conceded that the writer who is in active direction of this execution is likely to attest with some knowledge and experience what the dredges can and cannot undertake.

What are the Minority's requirements? First as to distance. It may be seen from the detailed map of Gatun, that the nearest point from which a dredge or discharging barge could have access to the dam, would be where the old canal line and the Chagres River meet, *i.e.*, at the lower extreme eastern edge of the dam. No closer approach is possible, unless special canal extensions are excavated and the shallow river channels are opened. In addition to their great and entirely uncounted cost, such excavations even so small as 250 feet wide and twenty feet deep along the foot of the dam, would so enlarge the opportunity for destructive percolation and weaken the base, that they evidently should not be ventured. From the two points above mentioned therefore, to this dam let a radius sweep a curve which will include the whole length of the dam. It will be seen that this radius must be fully 6,500 feet long. By the Minority's description and estimate given above, the heights through which it is proposed that material shall be pumped is up to 80 feet, probably, and 50 feet certainly. This is the task for whose accomplishment they rely on the Galveston dredges—a 50 to 80 foot lift at the end of a mile and quarter of pipe line. The Galveston dredges or any others ever built might as well try to pump to the moon. Further, increasing the size would not enable them to do it, because of the mechanical limit of the method. The Galveston order is not at all the most efficient type for this Gatun dam proposition. But even with the best, the highest accomplishment yet recorded is a 35 foot lift at the end of a 2,000 foot discharge pipe. The practical limit of the largest dredge at Galveston is at the end of 4,500 feet of pipe, a twelve foot lift, which she will reach in filling the far west end of the city. None of the other three dredges can achieve even this, which is the record of the largest and most successful example of the type yet evolved. A relay pumping system is experimental for this duty and has nowhere been successfully employed.

To use ordinary suction dredges which cannot steam with their load and discharge ashore, would leave the task still more impossible, because the distance is prohibitive for direct pumping. There is not an engineer or executor of hydraulic work in the United States who can discover one type of hydraulic machine, on the whole wide surface of the globe, that can complete in the prescribed method the Government's dam upon which the entire existence of their canal is resting. There is one thing absolutely sure. The combined Commission and Minority and special pleaders are basing their waterway upon a dam to be constructed by a prescribed process and this process is a will-o'-the-wisp. Unless some other method is employed, or a new machine is invented quite revolutionary in its accomplishments, the central monument will never be erected.

The foregoing has been a discussion of dredge capacity in sand, such as obtains at Galveston. It is in order next to examine the Panama material.

The excavation between Gatun and the 45-foot sea-contour is given as 20,330,000 cubic yards. Of this the dam is to employ 17,940,000 cubic yards. Thus all the excavation between these two points is used, save about 2,490,000 cubic yards.

We will analyze the nature of the excavation, then assuming that all of the most refractory material is not to be used, deduct this 2,490,000 cubic yards from it. What is left is the filling proposed for the big dam.

The Majority estimate still to be dug from the partially excavated French canal, 2,357,154 cubic yards of refractory material in their sea-level to mile 5.49. The line of the Minority is different. It is closer to the Sierra Quebrancha Hills; hence it is certain naturally to encounter more refractory material. But its sponsors claim to have in their excavation between Mindi and Gatun much less indurated clay than the amount which the Majority figure. Is it at all credible that the Minority has reckoned enough refractory excavation? One must conclude from a careful study of all available data that between Mindi and Gatun especially the refractory quantities allowed by the Minority are far too small.

The Gatun Dam.

Inquiry has developed the fact that except at the intersection at the mouth of the Mindi, neither the Minority nor the Commission had in hand from there to Gatun, a distance of nearly four miles, a single boring on which to base the estimate to which all their responsibilities are attached. There existed neither a profile of the surface, nor one of the indurated clay. Their new line is a merest paper location away to the eastward of all the canal excavations of the French company, and therefore away from all accurate knowledge of actual strata. Four miles without a boring, one-tenth of the distance from sea to sea, estimated in open guesswork!

From an examination of pertinent maps and a familiarity with the history of the abandoned French diversion to Manzanillo Bay and from the accuracy of the data of the Majority, and of the old canal alignment, remembering that on this section the Minority project is over *three* times as wide as the sea-level project and runs partly amid clusters of small hillocks, it becomes almost a certainty that the indurated clay in the Minority's estimates is vastly underrated, but by what amount no one knows. When the line is actually surveyed, if it ever is to be, and bored, it will undoubtedly be found that they will have over three times, (since the cutting is thrice the width of the other), as many cubic yards as they now contemplate of rock-clay, refractory from a dredging standpoint, or at least 6,090,000 cubic yards.

Deducting from this estimate of the amount of refractory clay, the 2,490,000 cubic yards of excavation that is left above what goes into the structure, there remains 3,600,000 cubic yards of refractory material " to be pumped into the dam." How can they get this deposit which, next to submerged rock, is the hardest on the canal to manage, pumped? The only competent bid ever submitted named $1.50 per cubic yard for simply putting it on the adjacent banks,—over double the official unit price.

The only conceivable way is for the material to be lifted from its bed and put into barges by bucket, or preferably, by multiple-bucket dredges, with more or less use of powder, because the material, a dense unstratified rock-clay, is very questionable for a Lobnitz breaker. With such dredges much of the stuff deposited into the barges will be in large lumps, in sizes up to a cubic yard or more. The material is manifestly in no condition for being " pumped from the barges into the dam." It must be granulated first mechanically. To such service the cutters of a suction dredge at the dam stations cannot be suited. There is no way for effecting this, save by cumbersome and untested process of stamping, crushing or granulating. When wet, the prong armored bucket-lip of a dipper dredge could hardly pierce it; dry it is almost like sandstone in consistency.

It is the material upon whose rock equivalence the Commission is trusting to up-build for foundations to the massive locks at Gatun. It is the stuff, specimens of which Senator Knox passed around to convince his fellow legislators that it was indisputable rock, when the type vote was concerned.

Mr. Stearns also testified: " As one handles it and looks at it they would call it rock and that is what it is, a fine-grained rock. I found by taking the knife that I could cut it. It looks something like a fine-grained whetstone, only it is softer than the whetstone that you use."

Senator Knox: " I tried the other day with a knife because it looked exactly like soapstone. I got that impression when I picked it up."

Mr. Stearns: " For any such pressures as come here that is just as good a the hardest rock that you ever saw."

Hydraulic dredges with cutters cannot excavate this Mindi clay-rock at any price warranting the consideration of their use. Much of the material will have to be drilled and blasted, or Lobnitized, and the ingenuous proposition to dredge the refractory clay-rock by means of a suction dredge with cutters and put it into barges is, to one with first hand experience in building and operating, simply preposterous.

Next, the whole surface of the swamp is an interlaced jungle of mangrove and tropical thicket. A dredge would have the greatest trouble with such conditions. The section would have to be first treated to a careful grubbing out of all roots. Besides the top strata would not deposit well in hoppers. So there is very probably 5,000,000 cubic yards of the specified 17,940,000 that either cannot be handled by any hydraulic dredge, or to employ which would impose a unit cost well on to double that calculated. So much for 5,000,000 cubic yards of their dam material.

But more of the supply to build this crucial dam is to come from silt, dredged in Limon Bay. Now, the material in Limon Bay is very light and soft. A rail used for sounding penetrates many feet by its own weight. It is not proposed by the Commission to provide the breakwaters at present. (Letter B. R.) This means that the water of the Bay will nearly always be, from the trade winds, too rough to permit the use of dipper or clam-shell dredges, or suction dredges discharging into barges. It will necessitate the employment of self-propelling, self-contained hopper dredges of large size and special design, fitted to discharge their silt cargoes into the dam when the vessel has steamed to Gatun.

This silt, jelly-like, under the weight of the ocean will remain mud-jelly in the dam—a sliding cushion for whatever is imposed upon it—and itself molten as lava. *This in the heart of the dam and this dam the heart of the country's project!*

Further, material of this lightness will not deposit well in the dredge hoppers and only in such small quantities per load as to render the whole performance a fiasco. There are fully 5,000,000 cubic yards of this silt out of the 8,300,000 cubic yards from the bottom of Limon Bay, which the Minority have counted on and figured to excavate and transport to Gatun at the interesting rate of fifteen cents per cubic yard.

There remain about 8,000,000 cubic yards of earth which can be excavated with dredges in an efficient manner. But to what avail when the vicious circle comes back to the impossibility of pumping this into a dam with machines, the greatest performance of whose best type has been a lift of 35 feet at the end of 2,000 feet of discharge pipe? The authorities propose therefore to handle 27,000,000 tons into this dam, much of the material so refractory that it will have to be specially cut and granulated; and more of it too light to be deposited into transporting hoppers and stay there. This tonnage is to be carried some of it through the half refilled French canal, now narrower than that at Galveston and two or three times as long which must be opened and maintained; part of it through distributing channels necessarily subject to the escaping flood currents of the Chagres.

There is employed at Galveston a plant costing $700,000, for placing 270,000 tons per month of good easy sand on the area of the city to an average elevation of twelve feet. This rate shows that one hundred working months, or eight and one-third years would be consumed if similar conditions obtained at Gatun. Supposing that the authorities insist upon trying to experiment, what outlay will be involved? Having regard to the far less favorable material, to the longer and more involved transport, to the conditions of distributing at spoil stations, climatic conditions, malarial surroundings, etc., the floating plant should be at least treble that used at Galveston, since at most but one third the number of trips could be averaged.

It is safe to say that the dredging and transporting and distributing plant for Gatun would cost easily, including the work of preparing the waterway approaches, $3,000,000.

The construction and installation of the machines and opening approaches will consume one and two-thirds years, giving a total of ten years.

To do the work in the nine years of the Minority's estimate will demand still more plant costing $500,000, making an outlay of $3,500,000 for dredges, barges, shore stations and canals. $3,000,000 of machinery, no part of which is to-day ordered.

The official estimate and allotment for putting these materials into this dam, by the prescribed process is:

12,170,000 cubic yards at 20c. to elevation 50 feet	$2,434,000
5,770,000 cubic yards at 30c. to elevation 80 feet	1,731,000
17,940,000 cubic yards	$4,165,000
Dredging 10,000,000 at 25c. cubic yard	2,500,000
7,940,000 at 15c. cubic yard	1,191,000
	$7,856,000
Deducting for preparation and plant	3,500,000
Leaves for handling 17,940,000 cubic yards	$4,356,000

This is a rate of about 24c. per cubic yard for dredging, transporting and pumping into elevations up to eighty feet. The sum would be inadequate for putting such a tonnage to an average lift of only ten feet at Gatun, let alone relaying it to these experimental heights.

The method is, however, applicable to a low dam at Mindi or across the lower Chagres because the clay-rock and the light silt are avoided. It is feasible for a dam at Gatun with a net head of thirty feet. This is because the mechanical and proved limit of these machines is not exceeded. In the case of such a net head dam at Gatun, Lake Chagres would first be created at 33.5 and then every part of the Gatun dam becomes accessible by water without digging a network of canals and river channels, subject to flood, for the dredges, barges, floating plant and supplies. As the low dam at Gatun requires but 1,000,000 cubic yards of dredgings this could be taken from the layer above the clay-rock.

For the great Gatun dam there can be no alternative, before or at the end of experimenting, save to openly abandon the solemnly prescribed method and bring down 15,000,000 cubic yards of spoil from Culebra and hoist it, and spread it, and puddle it into the dam,—750,000 carloads. Besides 350,000 to 500,000 further carloads must be brought to make the great railway fills across the arms of Gatun Lake. Surely the Panama Railway will have abundant traffic between Culebra and Gatun—400 twenty-yard cars each way per day for ten years bearing earth and rock alone.

As the lock flight was shown to be unexampled, unparalleled and unprecedented, so is this colossal dam under the selected method of construction. Here again, therefore, experiment is enthroned King, and experiment foredoomed to disaster.

The next point to examine is whether such a dam, if it could be constructed at whatever cost, would be desirable. Assume for the moment that it were built in some way at some expense, what is it when finished? A structure of mammoth size, holding back a large deep lake and the foundations for it, such, that a great proportion of the government's own engineers condemned it unqualifiedly.

The objection is not to the site. A low dam with a small head of water can be installed on alluvial strata with perfect safety, as dozens of examples verify. But the immense test which such a vast pile as is contemplated will put upon such foundations, and the dire consequences at Panama of failure from any cause—these are the conditions which have brought such concern. The Gatun formation with a properly constructed low dam can hold up a thirty foot head of water till the crack of doom; no question has been raised as to this. But can it hold back the tremendous pressure of eighty-five feet and its own weight? How doubtful and debatable this is, the Senate testimony and the report of the Majority of the Board particularly emphasize, for this dam was the nucleus of the condemnation of every member of the Majority.

Their report was signed by the following engineers: Davis, Parsons and Burr for the Americans, Hunter nominated by the British Government; Tincauzer by the German; Guerard by the French; Welcker by the Netherland and Quellenec by the Suez Canal. They wrote: "There are grave reasons for doubting the stability of these types of structures under such conditions." . . . "These are disquieting considerations in the design of dams to retain water of depths varying from thirty to possibly eighty-five feet or more." . . . "Unless some feature equivalent to that of a heavy masonry core characterizes the design of the dam at this point (the Minority's at La Boca), or unless resort be made to dredging down to bed rock, or near to it, and refilling with suitable material, or an earth dam at this location be made very massive it would be in grave danger of being pushed bodily out of place by the pressure due to the head of water in the reservoir." "The Board is unqualifiedly of the opinion that no such vast and doubtful experiment should be indulged in, but on the contrary that every work of whatever nature should be so designed and built as to include only those features which experience has demonstrated to be positively safe and efficient."

Thus strongly and uncompromisingly did the Majority of the International Board put themselves upon record against the Minority's high heads and massive dams.

Before the Senate Committee the three American members gave extended details to the objections. To theirs was added the testimony of two other engineers. One stated: "It is nothing short of monstrous to jauntily rest this national enterprise upon untried methods vastly beyond the range of experience and past success." The other testified: "The result will be a tendency for that dam (the Gatun) to crack on lines perpendicular with the edge of these gorges . . . and those fissures will have a tendency to let the water through them and will have a tendency towards weakening the structure."

Senator Morgan: " Would not such a fissure as that endanger the sweeping out of the entire structure from end to end when the water was at a height of 80 or 85 feet? "

Answer: " It would have a tendency to make a break in the dam where these fissures occur."

Senator Morgan: " When a fissure occurs under a head of 80 or 85 feet of water."

Answer: " It is generally disastrous."

Senator Morgan: " Disastrous? "

Answer: " Yes."

Senator Morgan: " Can it be otherwise? "

Answer: " Of course, I would not like to say that that thing would actually occur at that point."

Senator Morgan: " No; we do not any of us attempt to say what will occur in the future."

Answer: " But I would not take the chances on it."

These few quotations hint the cumulative condemnation heaped upon the central engineering element of this great national work.

These engineers had some cold facts, be sure, back of such strong verdicts. There is at Gatun a geological V, whose bottom is known to be at least 268 feet below sea-level. It is accepted that the sides of this V are of indurated clay-rock and that the material between, is river drift and soft alluvial clays and earths. The natural deduction from this is, that under the enormous pressure of a dam 135 feet high the soft strata may sink, or slide along the hard side rock and by displacement give rise to a subsidence or fissure in the dam. There is not a certainty of it, but there is a possibility of it. Subsidence may mean very little or very much. It may mean a few inches variation in height, or a gap through which the eroding lake can eat the whole dam out in a day.

The fact of the geological formation is established and the other facts likewise, but the Commission plan centers all the canal's risks regardlessly, on one huge structure. It defies the principle of averaging chances over many small units, any one of which could be readily repaired by itself. This concentration of risk is a short-sighted matter. If an earthquake, rupture, subsidence or fissure should open the way for the waters, nothing could halt them. The stored-up fury of a loosened lake, twenty-seven miles long, sweeping down from a height of eighty-five feet, would utterly and completely annihilate both barrier and canal.

The Gatun Dam.

A breach in the writer's advised low dam would as in the case of the high dam, of course empty the upper lake to the level of the lower. But the released waters would be stayed by Lake Chagres for a time sufficient to enable the opening of all the sluices at Pedro Miguel and Mindi drawing off 200,000 c.f.s. The low lake level would be further regulated by emergency spillways, incorporated in the Mindi and lower Chagres dams. The break could thus be confined to the dam; Lake Chagres would remain intact and in twelve hours the work of repair could begin by powerful dredges. In event of serious breach in the advised low-level Gatun Dam there would still remain some eleven feet of water in the upper lake held by the Mindi dams. The Canal would be out of full depth service simply the time it took to accumulate 29 feet of water in Gatun Lake—a matter of the season in which the accident occurred—three to six months.

It is most unlikely that the waterway would be closed to any but the very largest vessels for over six weeks. An 85 foot canal would be closed over six years.

There is a disclosure here in regard to borings and drawings which is of passing interest. We quote from the Senate testimony, page 1911:

> Senator Morgan: " Some statements have been made about it that have astonished and alarmed me by geologists. I do not pretend to be anything approaching that sublime state of civilization. . . . I shall not be here this afternoon and I suggest that it is very necessary to have copies of this blue print made for the use of the Committee and the Senate (referring to blue print profile, the original from which plate twelve was prepared). It is the most important document that is in the whole case."

The Chairman: " Very well."

Senator Kittredge: " I agree with you, Senator, about that."

The Chairman: " That seems to be the only copy that the Commission possesses. They sent it down to us and they say that it is the only copy that they have."

Senator Kittredge: " They sent us what purported to be a copy, but it was not."

Senator Morgan: " It is a very precious thing if that is the only copy that they have got and it should be printed at once. I hope the Committee will pass an order that the Chairman be requested to apply for permission to have it printed."

The Chairman: " If there is no objection, that will be done."

The printed profile " No. 12 " is photographed. It shows on being scaled as any engineer can verify for himself, from the East to the westerly end, 9,500 feet. Nowhere in the Minority report is this figure of 9,500 feet (from which is to be deducted the width of the twin locks some 300 feet) or around 9,200 feet of crest length given for the Gatun Dam. There has been no reference to any further construction than that of the 7,700 foot measurement " from the locks to the western end."

This one and only map, " the most important document that is in the whole case," shows further that the designers swung a thousand feet of the west end of the dam 1,000 feet northward to another spur. The profile drawing and chart of borings reveal that there was not a single exploration or boring in all this length under the crucial structure. No stratification profile existed and the location was made with no data whatever for a basis. Surely before such a dam was indorsed by Minority, Commission, Chief Engineer and Secretary of War there should have been some reliable and adequate determinations of its actual, not of its guessed relation to the stratification. As to one seventh of its computed length therefore, the stupendous Gatun Dam also had a mere superficial paper location.

Returning to its general objectionableness and menace one asks what is the way to escape the mammoth of experimental engineering? It is to reduce it to the bounds of conservatism and safety. It is the same solution as that by which locks in flight are avoided. Lower the lake level—an 85 foot lake serves no navigable end which a 60 or 62.5 foot level will not amply meet.

As the hills here at the Isthmus are characteristically steep the area of a lake at 62.5 is very little less than one at 85—probably 105 as against 110 square miles An 85 foot lake serves to reduce some excavation between Bohio and Paraiso, but this is a saving purchased at too dear a price in a three lock flight and a gigantic dam, and 10,000,000 cubic yards of railway fill.

Transit through a canal at 62.5 feet would be certainly as safe and rapid as through one at 85 feet. A small Gatun dam can be built under so low a head that vexed problems of construction are eliminated and stability upon Isthmian foundations becomes safe. If there be constructed at Gatun a dam on which the net head is, say thirty feet instead of eighty-five feet, the water pressure is reduced to nearly one-third. and its own weight is diminished 80%. The proposition is taken then from the realm of empiricism and brought within the domain of rational engineering.

Another element calling for surely some consideration is the excess discharge of the Chagres below Bohio which has been forgotten or overlooked. The Gatun sluices provide a regulation for 140,000 c.f.s. (Board Report, page 73). These were arranged to accommodate the flood of 1879. But this amount was the discharge past Bohio. Past Gatun there went, according to the Board's own reckoning, 67% more, or 233,800 c.f.s. The Minority apparently moved their dam bodily to Gatun from Bohio and have ignored the flood contributions of the Gatun and Trinidad and Culebra-Pacific watersheds raising the standard to 240,000 c.f.s. Here are certainly some important, additional lake and dam considerations to be counted in, and some more relief and safety provisions to be supplied.

In view of all the facts what should be projected at Gatun? The summit level (which would vary a trifle according to the storage in Lake Gatun) should be set at between sixty and sixty-two feet. At Gatun, install the canal's low summit level dam, whose lower face will be pressed by the Lower Lake at 33.5 level. The difference of these levels will represent the pressure on the dam—normally twenty-nine feet, but in times of greatest storage a foot or two more. This will never be enough to occasion any peril or misgivings with the provisions made for safeguarding it.

At once by this lowering of the lake and consequent securing of a conservative dam, the perplexities in which the Government has been enmeshed here, fall away. The low dam has no problems of construction; it can be built where needed by the economical hydraulic method. It contains but 4,635,000 cubic yards of material of which but 1,000,000 cubic yards is to be placed by dredges. The lower lake gives access by water to every part of it. The highest pumping demanded is thirty feet with 1,500 feet of radius, all within the bounds of experience and of continual practice. A dredge would steam up the lower lake, having excavated the suitable material and discharge the small height over into the dam.

The lower head of water and the relatively slight pressure on the strata below eliminate danger of subsidence. The one eventuality—that of an earthquake—cannot be guarded from. But a small object is far safer than a great object. A rift could readily be repaired by well proved methods. The dykes of Holland, having this head and in more dangerous proximity to the sea, have been constantly maintained. But if notwithstanding all, the dam, always protected, were still to go, which would be the ultimate possibility, its volume could be mechanically replaced by dredges and barges in a comparatively short time and with relatively small expense. To restore the Commission's dam would demand the excavation, by the old costly process, of this same vast amount of material under conditions much more adverse than obtained in the first construction. To merely refill its lake with water would take nearly a year.

The way of salvation is therefore plain. The right disposition is clearly shown. It gives escape from locks in flight; it averages risks over many units and reduces those risks to the lowest possible; it substitutes a low and safe dam for the Commission's lofty and dangerous one; it gives a reasonable solution to the canal.

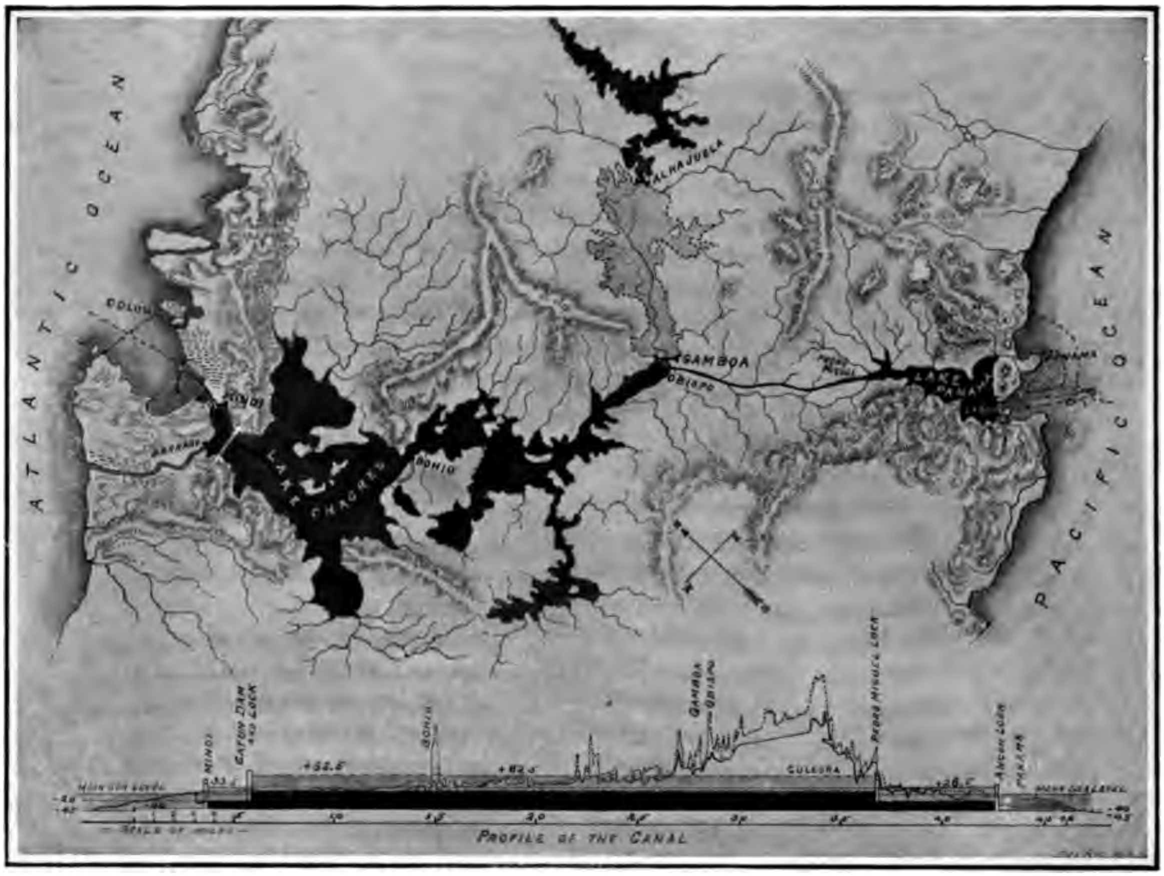
The general design herein advocated is the best lock canal for Panama. The Minority comparing with these special features, their own, allow its superiority in every fundamental element which has been detailed. They wrote, page 79: " The advantages of this project are:

" The smaller head of water to be sustained . . than by the Gatun Dam in the eighty-five foot project.

" The smaller height of embankments required to maintain the intermediate level between Pedro Miguel and Sosa, the water surface being twenty-eight feet lower."

" The summit level would be lower and the locks reduced in number from six to four, there being no flights of two or more locks, but only a single lift at each locality, a transformation to a sea-level could be effected more easily."

Every vital fact of technical superiority, therefore, for which this series has contended is categorically attested by the Minority themselves.



THE THREE LAKE CANAL.
Plan showing how the summit elevation of 62.5 ft. is reached by four locks without any dam sustaining a permanent head of more than 35 ft.

THE GATUN LOCK SITE.

Now that the Minority's plan has emerged from the vexed sessions of the Committee Room and has had nine months in which to fortify evidence and get "modified,"what approach to engineering ideals has ben evclved?

The two main elements of their canal continue—the great earth dam and the lock ladder at Gatun. These constitute the heart of their project by which it must stand or fall. Gatun Lake held by the stupendous dam is to be 85 feet above the surface of the channel below. Three locks, raising and lowering ships through this 85 foot lift are installed in tier, one above the other, on an artificially elongated Gatun Hill. Each lock, as planned by the five members and supported by the Commission, was to be 900 feet long and to have two safety gates which reduce the available length to 820 feet or less. The gate width was to be 95 feet and the sill depth 40 feet.

In coming to the consideration of locks the gauge of size had been established in general terms by law. The Spooner Act authorizing the waterway was explicit in its stipulation that the canal must afford a safe and convenient passage for the largest existing ships, as well as for those larger ones which might reasonably be anticipated. The International Board had, as one of their first studies, the determination of the lock dimensions which would satisfy this fundamental requirement of the Act. It was noted that every important waterway in the world was being outgrown at a pace which it was quite unable to meet. The biggest Australian ships had ceased attempting the Suez and were again going the long route around the Cape and this although the Suez was in continuous process of deepening. The Manchester opened only ten years ago was already being enlarged; as was also the Amsterdam; the Kiel was about to be enlarged; the Soo was adding locks and even a state canal, like the Erie, was voted $101,000,000 to get dimensions into adequacy for the increase in sizes, The Board collected statistics of growth; they noted of the Cunard steamers that those laid down in 1905, were "23% longer and of 21½% more beam than those in use the year before," "and there seems to be no recognizable tendency to discontinue this expansion of dimensions of deep sea vessels." Already "The Cunard Company has under construction two steamers eight hundred feet in length and eighty-five feet in beam." They decided, in summarizing their studies, "that the convenient passage there, will within a quarter of a century be used by ships 900 feet long and 90 foot beam seems not at all improbable" (page 37).

They adopted a quarter of a century as the interval which the canal should serve without needing enlargements to meet the legislative stipulation regarding "those which might reasonably be anticipated."

In conclusion therefore the following was decided: "As a basis of all plans the Board resolved by eleven affirmative and two negative votes that locks should have as *minimum usable dimensions* a length of 1,000 feet, a width of 100 feet and a depth of 40 feet. The two members voting in the negative were Messrs. Noble and Ripley."

Later in the month the Minority members seem to have become so overwhelmed by the size of the great national work that they got to thinking of everything in terms of hugeness—huge lakes; huge dams; huge tiers of locks—such alone were the elements befitting this huge undertaking. The Majority strove to recall them to bounds and balance, but futilely. So the parties divided the Majority recording their solemn warning as to the inadequacy of shorter locks and the perils of flights of locks. These "are much more vulnerable than any other essential accessory that has been proposed to be used in any type of canal that has been considered by the Board and this jeopardy is considered to be a very grave one."

Nine hundred foot locks are therefore deprecated and flights of locks branded as the very worst and most dangerous feature proposed for any canal.

Such a flight of locks as is proposed here at Gatun is unexampled, unparalleled and unprecedented in the whole existing world. It is a daring and herculean experiment, to be attempted for the first time in history. These structures therefore as to their foundations, their arrangements, their construction and their facility for manipulation should be beyond any question or challenge whatsoever. They should be so entrenched in conservatism and safety that they can stand technically invulnerable,—this and this only would give warrant for decreeing an anomaly with no precedent as a guarantee for its success. For all the facts in regard to these two features centering and compassing the very existence of the canal, one must go naturally beyond the arbitrary *ipse dixit* of five men sitting in secret session upon their own project. Every element of the proposal must be weighed and measured nakedly against incontrovertible evidence.

The first and indispensable requisite for formulating a plan of any kind is data. The greater and more vital the feature, the more comprehensive and detailed must be the data. For an unexampled flight of massive concrete locks the need of the right foundations is so glaringly self-evident that complete and exhaustive information was imperative before any valid engineering opinion, even upon the possibility of locating there a tier of locks at all, could be entertained. What then is to be said to the confession forced from them by the Senate Committee that the Minority voted and recommended this flight of three locks at Gatun, when but " four borings, or rather three," had been taken on its entire site?

The following is the official testimony given before the Senate Committee, page 1844:

Senator Kittredge: " To what extent had your Board and have you in your possession information concerning the character of the Gatun Hills in the vicinity of the proposed locks "

Mr. Noble: " There are some borings in there, but I do not think they extend the full length of the lock. There was no time to get all that information." . . .

Senator Kittredge: " Do you not think it was desirable to have that information? "

Mr. Noble: " Oh, extremely."

Page 1793:

Senator Kittredge: " How many borings were made in the Gatun Hill in the vicinity of where the locks are to be placed? "

Mr. Parsons: " There were nine borings made, I think, Senator, on a different location. This map shows them. There were seventeen borings made altogether, and it was figured at that time that the locks should take that direction, as you can see by those black lines." (Indicating on the map).

Senator Morgan: " The seventeen borings were on the lock site? "

Mr. Parsons: " On that lock site. Not on the lock site that was finally adopted. The seventeen borings were made on the first lock site as proposed by the Committee. Then they found that the hill in that section was too short to accommodate the locks and the location was therefore changed .. .. .. so that these borings down here give no information at all as to the condition of the lock farther to the east. Therefore as a matter of fact there are four borings or really three that come within the lines of the lock as shown by the Minority report."

Senator Hopkins: " How far out are they, Mr. Parsons? "

Mr. Parsons: " That distance is 500 feet. You can see that all these borings down to the west of the canal on the lower part are from 500 to 1,000 feet away."

Senator Hopkins: " From the actual location of the locks? "

Mr. Parsons: " From the actual location of the locks. And if you will refer to the plates showing those borings there given in the Report, you will see the indurated clay for instance, which is the material on which they expect to found the locks and how it will vary in position between two borings. You see it is liable to fluctuate very widely?"

Senator Knox: "It is liable to fluctuate widely within what distance?"

Mr. Parsons: "Oh, in a distance of two or three hundred feet it would fluctuate very widely. .. .. .. You can see how close the borings were made there (indicating), and on the site of the locks no borings were made at all."

Page 1981:

Mr. Wallace: "In my own examination of these borings—there have only four or five borings been taken throughout the entire site on which it is proposed to build those locks, which, with their approaches and wing walls, extend upward of a mile in length and my criticism on the lock plan was this .. .. .. And it would seem the part of prudence before a lock plan of that magnitude and importance is undertaken that the most thorough borings should be made over that entire area and at least as close together as 100 to 200 feet apart, both laterally and longitudinally."

Senator Dryden: "These borings have not yet been made then?"

Mr. Wallace: "I understand that they have not." (Senator Kittredge's speech, page 1732.)

"They (the Minority) propose to construct locks having a usable dimension of 900 feet in length and 95 feet in width, three in flight and the lock structure, the guard walls, approach walls and all the other necessary elements of that design will make a structure more than one mile long. It will be observed, if one examines the map, that with one or two exceptions not a boring has been made under the site of the proposed locks at Gatun to determine the foundation."

On superficial knowledge of four holes therefore the monster experiment of all time was formulated by the Minority and supported by the Commission and the Secretary of War, with all the enginery of the Government backing them. So reckless and unprofessional a system of engineering could not be found in all American annals.

What next, is the situation in regard to the locks themselves? The record is a fitting parallel. These locks were announced in the text as 900 feet long. The Majority be it remembered had strongly protested against the incorporation of any lock at Panama with a minimum usable length of less than 1,000 feet, and these full length locks had been recommended by 11 to 2 in the Board. But these five members of the Minority when they conceived the vicious tier system were impelled to ignore the vote and shorten the length to 900 feet. The official drawings were given out with the text.

The Senate testimony reads, page 1639:

Mr. Bates: "The Minority's dangerously conjoined three Gatun locks are stated to have usable lengths of 900 feet. These lock lengths are 790 and 820 feet on the official papers they have themselves put out and which are endorsed by the Commission and the Secretary of War." .. .. ..

Senator Dryden: " Do you mean to say that the report of the Commission is false in that respect? "

Mr. Bates: " I say that their location and the official plans to which they have subscribed, shows locks that are but 790 feet in usable dimensions."

Senator Dryden: " While they claim them to be 900 feet."

Mr. Bates: " They have not shown it, sir."

Senator Kittredge: " The question was, they claimed them to be 900 feet."

Mr. Bates: " Yes, sir, they claim them to be 900 feet. My position in regard to locks at Gatun and their practicability is that there is safe and ample room on easily reached rock foundations for one long lock and its approaches and that there is not room for these three short locks and no room for further enlargement." .. .. ..

Senator Kittredge, page 1751: " Before you begin Mr. Parsons, I would like to call your attention in that connection to a statement made by Mr. Bates on Saturday, as I recollect, to the effect that while the report of the Minority gives the usable dimensions of the locks at Gatun as 900 feet by 95, the fact is they are less than 800 feet."

Mr. Parsons: " I think I can explain Mr. Bates' criticism. This sheet I lay before you is Plate XI of the report of the Board of Consulting Engineers, in which you see the Gatun dam and the three locks in flight."

" If you will scale off the distance from this map you will find that they have got 900 feet in the clear between the outer gates, but only 790 feet in the clear between the inner gates."

Senator Kittredge: " You mean by the outer gates the lower gate at the lower lock and the upper gate at the upper lock? "

Mr. Parsons: " They double the gates all the way through, at each lock."

Senator Kittredge: " And have they accounted for that doubling? "

Mr. Parsons: " They have accounted for it simply in that way—by subtracting it from the effective length of the lock. In other words, if the double gates are to be used, then the lock has an effective length of something less than 800 feet. If the double gates are not to be used, then they get an effective length of lock of 900 feet, as they have planned."

Senator Kittredge: " What is the length of the largest ship now being constructed? "

Mr. Parsons: " Seven hundred and eighty feet, I think—one of the Cunarders."

Senator Kittredge: " Could that ship go through this lock? "

Mr. Parsons: " It could not, unless they left the safety gates off. Then, of course, the criticism comes right back to where the Majority members of the Board opposed the lock scheme—that there is no safety device against a vessel plunging through."

Senator Kittredge: " Did they agree with you that the safety gate should be put in the construction? "

Mr. Parsons: " Apparently ;they put it in."

Senator Kittredge: " Then in your judgment the danger of crushing down through these locks is always present? "

Mr. Parsons: " I do not think there is any doubt about it, that is my criticism of a lock canal."

Senator Kittredge: " You mean even with the safety gates added? "

Mr. Parsons: " Even with the safety gates added; and, of course, you must always remember in that particular case that with a very large steamer, where the safety gates could not be closed—they would have to be open, because otherwise you could not get her in—you would have no safety device as against the most dangerous type of vessel. The larger the vessel the more difficult she is to handle, and the more difficult she is to stop. Her momentum is greater by reason of her greater weight."

Senator Kittredge: " Then, as I understand you, notwithstanding the statement in the Minority Report of the usable dimensions of this lock as 900 by 95 feet, in the plan presented to us the usable dimensions are in fact 790 feet as to length."

Mr. Parsons: " That is a fact."

Senator Kittredge: " By what width? "

Mr. Parsons: " Ninety-five feet."

Senator Kittredge; " Is it not possible to lengthen the entire lock structure so as to have a usable length of 900 feet? "

Mr. Parsons: " It is not possible to do that and still keep the three locks in flight."

Senator Kittredge: " Why is that? "

Mr. Parsons: " The topography of the ground, falling off at both ends, that you could not get a longer structure in there."

Mr. Parsons, page 1764: " But I was merely explaining the question that Senator Kittredge asked in explanation of Mr. Bates' criticism that the locks only had a length of 790 feet and not 900 feet. I was explaining that that was a fact and why it came about."

Senator Kittredge, page 1843: " The statement was made by Mr. Bates, and cofirmed by Mr. Parsons, that while the Minority had in its report recommended the establishment of locks of navigable dimensions, 900 by 95 feet, the plans which have been sent up here disclose the fact that the usable length of these locks is only 790 feet. Have you any statement to make regarding that criticism of your plan?"

Mr. Noble: "The locks are estimated, and, I suppose, drawn on the maps for a length between gates of 955 feet, of which 55 feet is ample to provide for the movement of the gate at the lower end of the lock, leaving 900 feet that is clearly usable."

Senator Kittredge: "That is the supposition?"

Mr. Noble: "That is the fact, Senator."

Senator Kittredge: "The statement is made by each of them that the plans do not show 900 feet, but instead, 790 feet; and Mr. Parsons' statement was given to us Tuesday that he had made a personal examination of the plans in the office of the Commission. Have you any knowledge upon that subject?"

Mr. Noble: "No; I have no knowledge whatever. I made the plans of the lock myself, Senator; I made the estimates of them. I sketched out the plans of the lock personally and I personally made the calculations of the quantities. They are based upon a length of 955 feet in every lock chamber and of 900 feet clear available space for a vessel and the figures given in these estimates of the Minority provide for that."

Senator Kittredge, page 1845: "The reason I ask this question, Mr. Noble, is this: You remember appearing before this Committee four or five years ago?"

Mr. Noble: "Yes, sir."

Senator Kittredge: "And recommending strongly the Bohio dam? On that occasion you told this Committee that there was no doubt whatever about ability to go to bed rock and lay the foundations of the Bohio dam. That was right, was it not?"

Mr. Noble: "Yes; on the basis of the borings we had then; we were very certain."

Senator Kittredge: "I understand. Now then, when more careful examinations and borings were made, the fact was disclosed that instead of striking bed rock at 120 feet below sea level you had only struck bowlders, or at least had not struck the deepest point at that place. That is right, is it not?"

Mr. Noble: "I think the latter is the case, Senator."

Senator Kittredge: "And when more careful borings were made, the lowest point at the Bohio dam site was 168 feet below sea level. That is right, is it not?"

Mr. Noble: "I think that is correct, yes."

Senator Kittredge: "Suppose that the lock plan is adopted by Congress and then you make further and more careful investigations and the fact is developed that you cannot build locks there, what then?"

Mr. Noble: "I do not think you can apprehend any such result as that, Senator."

Senator Kittredge: "That is precisely the result that happened at Bohio, is it not?"

Mr. Noble: "It certainly is. The project of sinking caissons to full depth at Bohio is I think unpracticable."

Senator Kittredge: "And you advised that that be done at Bohio."

Mr. Noble: "Yes, that is true."

Senator Kittredge: "When you were before us four years ago?"

Mr. Noble: "Yes."

Senator Kittredge: "You say that there is more doubt about the locks: What doubt is there?"

Mr. Noble: "Because the borings are not sufficient, are not what one would demand before constructing a lock."

After Recess.

Senator Kittredge: "Mr. Noble, have you, during recess, examined the drawings in the office of the Canal Commission in reference to the usable length of the locks proposed at Gatun?"

Mr. Noble: "Yes, sir."

Senator Kittredge: "What do they show?"

Mr. Noble: "The published drawings seem to have been a draftsman's error in showing the lock chambers too short."

Senator Kittredge: "What do those drawings show?"

Senator Hopkins: "Let him furnish his answer."

Mr. Noble: "I did not measure this. This information came from General Davis. The draftsmen also informed me that they had made a mistake and made the drawings too short; but the borings have not developed a lock site long enough for three locks."

Senator Kittredge: "They have not?"

Mr. Noble: "No, sir."

Senator Kittredge: "To what length have those borings developed a lock site?"

Mr. Noble; "They have developed a lock site long enough for two locks and something over."

Thus the locks which were announced as 900 feet usable length and which the member testified he designed and drew himself, he confessed scaled upon the profiles something quite different. These were the locks which the Minority had put out, which the Commission had examined and accepted. The other Minority members fled at once to the refuge of a "clerical error."

The Gatun Lock Site.

Senator Hopkins, page 1932: " The plan that is proposed by the Minority provides for a flight of three locks of 900 feet each, I think? "

Mr. Stearns: " Yes; 900 feet of usable length."

Senator Hopkins: " Yes, usable length. Now the statement was made by Mr. Bates and I think some others that the space is not sufficient to provide for locks of that character."

Mr. Stearns: " The statement probably arose from a draftsman's error in this plan of the Gatun Dam where the locks are shown shorter than 900 feet of usable length."

Senator Dryden, page 1939: " Now let me understand. Is it true that the usable space between these inner gates is but 790 feet? is that true? "

Mr. Stearns : " I do not think it is."

Senator Dryden: " No; I understood you to say."

Mr. Stearns: " I think it only takes out *eighty* feet."

Senator Dryden: " I understood you to say previously that you thought it was a draftsman's error."

Mr. Stearns: " I thought it might result from that. It is possible that between the inner gates it may be only 790 feet. I do not think it would need 110 feet between gates. I do not see why it should."

Page 1941:

Senator Knox: " And the upper lock might be shorn off how many feet?"

Mr. Stearns: " I think it is 80 feet."

Senator Knox: " What would be the greatest length of vessel which could occupy that upper lock with both gates shut, both the safety gate and the regular gate? "

Mr. Stearns: " As nearly as I know it would be 820 feet."

Senator Dryden: " Can you suggest how we can get absolute information as to the usable length of these locks? "

Mr. Stearns: " The information is the statement of the Consulting Engineers as to what they propose, and the only question it seems to me that might arise would be whether there had been any mistake by which something should be made longer."

Senator Dryden, page 1939: " This is a matter, of course, which you are not in any way responsible for, but the query occurs to me if we are misled in an important matter like this, and this is certainly a very important matter, as affecting the lock plan of canal, whether we have any security whatever in depending upon other measurements and drawings made here by the draftsmen."

. . . .

But the Commission was more wary. Theirs was the last redoubt. If it could not be held by force it must be held by strategy. The long subtle defense of the 900 foot lock by Colonel Ernst was the bluff of a desperate lawyer, not the open fighting of a soldier. When driven to the wall he rescued his locks at the open sacrifice of his ships.

Senator Kittredge, page 2041: " Do not say this one above that one; describe it so that we can put it into the record."

Colonel Ernst: " The distance of the quoin post of the guard gate from the other gate is 80 feet, and it would encroach that much on the usable length of the lock if you had to keep all your gates closed at the same time."

Senator Kittredge: " In other words, it would reduce the usable length to 820 feet? Is that it? "

Colonel Ernst: " That is it. Yes, exactly—if you had to close all your gates at the same time; but you do not have to do that."

Senator Kittredge: " Suppose you put a ship 900 feet in length into that lock; describe exactly what would happen in putting that size of ship through that lock."

Senator Taliafero: " What is the usable length of the lock with all gates closed? "

Colonel Ernst: " Eight hundred and twenty feet."

Senator Knox: " What is the usable length with the gates open, which you say may be safely opened after the vessel goes in? "

Colonel Ernst: " Nine hundred feet." . . .

This then is the last story—the Minority's locks are 900 feet when the safety gates are abandoned; 820 feet when the gates are closed. No wonder Senator Kittredge inquired: " What do you put those safety gates in there for? "

The investigation proved this in regard to the Minority's tier—they had length enough to use the ordinary safeguards for small shipping, but for large vessels, which surely had the greatest needs of protection, the safety gates must be thrown and kept wide open. The vessels therefore were to be at the mercy of the first chance. It was truly remarked that the Commission sacrificed the ships to save their faces.

In condemning this Gatun engineering as careless, inefficient and supremely reckless no word is needed save those which the Minority and Commission have themselves spoken.

But the object of this series is not to condemn, save as the showing will help to disclose in what manner and to what order of project this country is being committed. It seeks only to save the canal from another failure and disgrace and establish it in a safe success.

Since the Senate Committee did the yeoman service of forcing the truth, regarding the four borings, the Commission has tardily ordered more data, so at this writing a certain body of facts has been collected, which may be analyzed in another paper.

A profile showing the rock line as taken from the first series of borings along the axis, reveals distinctly that, whatever official opinion regarding adequacv and celestial concurrence may be claimed in behalf of a cause fighting for its life, there are *not* good and sufficient foundations for the Minority's three locks and their specified safety accessories. It is true that foundations for the Minority's flight of locks may be built up from the basis of indurated clay, but such locks should not be thus perched upon it. To give security, concrete must be incorporated at an enormous expense, which the figures given for the tier do not include or contemplate. The three locks are precariously perched over the brow of a hill too narrow for them and right safety provisions to fit into.

Next it will be noted from the profile that the locks, once built, cannot be lengthened without tremendous cost.

Senator Dryden, page 1940: " It has also been said here that these locks could not be lengthened. Now I understand you to hold the contrary view and certainly one or two other engineers hold the contrary view."

Mr. Stearns: " I do not see how these particular locks could be lengthened. What should be done in my opinion if larger locks are needed would be to build a third row of locks, etc. They could be built in the beginning adding roughly I should say $30,000,000 to the cost, etc."

Thirty millions—a mere bagatelle!

Page 1854. *After Recess.*

Mr. Noble: " But the borings have not developed a lock site long enough for three locks."

Senator Kittredge: " They have not? "

Mr. Noble: " No, sir."

Lengthening the center lock must force the upper one over the edge of the geological gorge, or all three must be lengthened downward. For the former a veritable Armada would be demanded to carry the concrete necessary to build up a firm foundation from the rock line. Certainly no traffic could go on during the many years in which this enlargement was taking place. Since the arrangement of three locks in flight practically precludes lengthening, it would have been wise to make the locks at whatever cost of full size at first. But the Minority's effective lock length as was shown, counting in the safety gates, which are assuredly more necessary for the great ships than for little ones, is really but 820 feet—a preposterously small margin for future growth, with the Majority writing, " the Cunard Company has now under construction two steamers 800 feet in length and 88 feet in beam. Military exigency requires and it therefore results that the dimensions of the canal and its appurtenances must be adequate for the largest vessels upon the oceans." (page 37.)

Next, there is the great defect that in their lock flight the Minority cannot make use of that device which has proved so valuable for safety, speed and the conservation of water—the divided lock. The system is this: A lock 1,000 feet long is divided by an extra pair of gates into two sections, one 400 feet, one 600 feet long, When a small boat is to pass through, the 400 foot section constitutes the lock and its gate is opened. A 400 foot volume of water only is used. The third gate is therefore always free and ready for the prevention of accident. For a larger boat the 600 foot section is used and for great ships alone the full 1,000 foot length. Thus there is nearly always a third gate available for safety purposes.

This most valuable arrangement is possible, however, only if three locks are not in flight. The Majority locks allowed it, but the Minority, whose need for safety was vastly greater, has sacrificed the dividing feature also.

In the light of but these most conspicuous facts it becomes apparent therefore that there are four vital technical objections to the Minority's lock flight here:

1. The tier arrangement is the most hazardous possible.
2. The rocky ridge of Gatun is too narrow for three locks to be themselves properly bedded on solid strata, with their approaches and the safety dam.
3. The 900 foot locks are too small for future vessel sizes and cannot be lengthened without limiting traffic and vast further expense.
4. The divided lock system is eliminated with its inherent advantages of water economy, speed in locking smaller vessels and the availability of an intermediate safety gate at sufficient distance that the momentum of a vessel breaking an intervening gate would be least likely to carry to it.

These are plain and unanswerable arraignments.. Is it possible to furnish a substitute free from these defects? If not then the criticism is gratuitous and unworthy.

The existence of an adequate solution is the warrant. Let but one lock be put at Gatun; make the lift not from ocean level, but from a 30 foot lake impounded exactly as is Lake Panama, which the Minority itself has adopted for the other end, but of half its height. Set the upper Lake Gatun at the 62 foot level instead of at 85 feet. With only one lock on this Gatun site the technical objections which hold against the three lock flight are resolved. One Gatun lock lifting between the levels can be located in Gatun Hill, so that the lock proper, the safety devices and both upper and lower approaches will be directly in or on the solid rock. No great backfill of concrete will be needed to buttress the walls; no up-building of masonry at lavish expense to secure a solid platform. At once the whole foundation question is settled by nature herself in the then sufficient dimensions of Gatun Hill.

Furthermore, the single lock is not limited as to length. The full and ample 1,000 feet of *minimum usable dimensions*—meaning a lock chamber close to 1,100 feet long, voted by eleven to two in the International Board of Engineers before the separating faction were obliged to cramp their convictions to fit an unaccommodating hill can be secured, and the possibility held of lengthening even this adequate dimension should necessity ever demand it. Finally the invaluable divided lock system can be employed to the greater convenience, speed and safety of most ships passing through the canal. There have been arguments against the whole lock idea, but since at Panama they cannot be entirely eliminated and the country is committed to a lock canal, let it have at least the right order and arrangement of locks.

Important as are these many technical defects of the Gatun lock ladder, the supreme evil is, of course, its hazard. The element of safety is quite sacrificed. This has been treated in an earlier chapter.

POTPOURRI--CULEBRA TO PANAMA.

The lower valley of the Rio Grande is a great triangular bowl in whose sea-rim have been worn two notches, one where the river seeks the Pacific, one between the sentinel hills of Ancon and Sosa. The project was simple, but far-reaching, of closing these gaps and impounding in the basin behind, a Terminal Lake, through whose unimpeded way the largest vessels could freely steam, under whose saving waters the fever laden swamps behind Panama would be drowned quickly and forever, and by whose plane the necessity for digging deep into the submerged rock would be eliminated. The Majority of the Board adopted and incorporated the feature in their advised 60 foot lock design; the size-bewitched Minority and Commission took it also into their 85 foot project, but in such excess as changed its saving grace into a bane. The import of this Terminal Lake principle was pregnant to the canal, and its content once clearly disclosed, its adoption by the Board of Consulting Engineers and by the full Commission was hardly avoidable. Its plan as introduced by the writer in his Panama project to the International Board showed the gaps closed, one by a low dyke and the other by a low rock-founded masonry barrage, through whose ample sluices the lake level was controlled. The lake was set at 26.5 feet above mean sea level. A primal reason for selecting this plane was, that under it the greatest head upon the dyke became 36 feet; *i.e.*, 26.5 feet plus the standard tidal fall 9.5 feet = 36 feet. One lock a thousand feet in minimum usable length, imbedded in the rock core of Ancon or Sosa Hill gave access to it. The low head of water put the practicability and security of the La Boca dyke beyond question, The combination was a safe, conservative and adequate engineering conception and the Majority incorporated it as proposed.

Another primal reason for adopting the lower plane was that owing to the smallness of the containing dams, at the earliest possible moment and with the minimum amount of work, the deadly swamps of the Rio Grande back of Panama could be submerged. Six months of time and less than a million of money would transform these breeders of otherwise unconquerable Chagres fever and malaria into the bed of a clear fresh lake, and the death-giving morasses be replaced by the life-giving waters. The 55 foot lake involves many years of delay and nine times the quantity of material in dams. It must ruin or take thousands of lives needlessly.

An initial mistake of the Government scheme, one which entrained the fellowship of the scriptural seven demons, each worse than itself, was the raising of the Terminal Lake to a height over double that which had been for such comprehensive reasons, set.

Lake Panama—a lake at 26.5 feet above mean sea level—was lifted to 55 feet and was re-baptized " Lake Sosa " The nomenclature by this grace differentiates the Government plan.

At its more than doubled height the impounded waters went above the rim of the natural basin of the Rio Grande east of Ancon Hill. Therefore in place of the two low sufficient dams of the original plan, three huge dams became imperative to confine their high deep lake. This was the first Satanic attendant. One of the three dams had to be interposed at Corozal between the lake and the City of Panama. This was a second sinister presence. Then for raising ships to the 55 foot elevation two locks must be intervened in place of one, and these two, owing to the conformation, must be set in the arrangement which experience has shown to be the most perilous possible, namely in flight. The third and chief demoniac was introduced. The high lake, besides, wiped out the Panama Railroad, which must be rebuilt at great cost further up the eastern hills, and a fourth wraith of destruction had joined the train. This intial error at Panama is the inauguration of an engineering eccentricity which becomes more amazing at every step across the Isthmus.

In examining in detail these features of the canal entrance at the Pacific, the high level dams come first to the balance for their weighing. What are their elements? Of the three shown, one is located across the mouth of the Rio Grande River; one between Ancon and Sosa; one directly behind the City of Panama, stretching from Ancon to Corozal Hill. Each crest is to be 90 feet above low ocean level. The combined crest lengths, since the rim of the bowl must be artificially raised for long sections to bring it above the 55 foot lake, are 12,150 feet—over two and three-tenths miles.

In considering factors of safety it becomes momentous first of all that the foundations are alluvial. To the engineer this means that there arises at once a very serious misgiving about letting a head of fifty-five to sixty-five feet press permanently on such long dams and sub-soils, under the exceptionally adverse conditions obtaining at the tropic Isthmus.

A low dam, if suitably constructed, can be safely built there. There is no question of this, when such practical examples as the levees on the Mississippi marsh soil, the dykes on the sand of Holland, or the Assuan Barrage on the silt of Egypt are visual demonstrations. But when the multiplying pressures of 50 to 55, and even at low tide, 65 feet, under treacherous conditions are incorporated, the conservatism of dams on such foundations is left behind. The realm of questionable experiment is entered and the canons of safe engineering are abandoned. The Senate Committee went into extensive examinations of this general question of the security of earth dams on alluvium under high head in Isthmian contingencies. The unequivocal testimony against them of Messrs. Burr, Parsons, Davis, Bates, Menocal and Wallace of America, Quellenec of the Suez Canal, Hunter of the Manchester, Tincauzer the German delegate, Guerard the French and Welcker the Dutch, is set forth in connection with the Gatun Dam.

The Pacific terminal section of the 85 foot canal as designed is dependent for existence upon these dams, which for their ordinary duty and service are by such collective judgment questioned. Aside from ordinary duty casualities, among other things, will be incident to possible breach in the dams themselves. Breach may arise from several sources. One of these is, of course, earthquakes. The displaced and distorted rails of the Panama Railroad, the ruined Cathedral tower at Panama City, the volcanic pits made at Bocas del Toro in 1888, and the crevasses opened near Colon, are evidences too tangible to be lightly explained away. If later testimony is needed there is a sinister reminder. " Colon, July 29. A slight earthquake shock was felt here at six o'clock P.M. yesterday."

No structure whatever is earthquake proof. In view of the haphazard miracles of survival and the equally haphazard miracles of disaster at San Francisco and Valparaiso, the stock references to the escape of the " flat arch " of the cathedral at Panama as a convincing argument that the locks and dams of the Isthmus will prove immune is as puerile as it is unworthy. The proportion of peril and of damage possible is the one only standard for earthquakes. A rift or crevass in a dam under a 65 foot head—indeed under any head—must be quickly stopped, otherwise the water would speedily scour and eat through it in a torrent. The contingency is to be well considered, because the very special handicaps to repairing the high dams, owing to inaccessible material and the length of time needed, become momentous here.

The three dams may be breached not alone by earthquake, but by overtopping; by unseen undermining; by subsidence; by pressure occasioning a dislocation, or by any other of several causes. The distinct probability of dislocation or subsidence from the mass and pressure of the projected dams at the Isthmus was testified to with ample warnings in the Senate examinations. P. 1538, 1635, 1798, 1801, etc., etc.

One must contemplate therefore with especial disapproval and anxiety one of these questionable dams, lowering, directly back of Panama city, holding a wall of water there in perpetual menace. With a rupture in this dam under the eating scour of a 55 foot lake, an avalanche of water would overwhelm the community in a catastrophe, which would leave only a chasm to mark its path.

Panama City is equally the objective for a break in the Pedro Miguel dam far up the canal, or a vessel over-running its lock gates. For Gatun Lake 110 square miles in area pouring its volume into Sosa Lake might top or breach the Corozal dam and the down-rushing water-wall likewise would sweep the city before it in consequences too fateful to contemplate. These are possibilities that must be callously acknowledged and accepted if the final decree is that the summit lake at 85 feet shall be combined with Lake Sosa at 55 feet.

This casualty of a Pedro Miguel dam or lock accident is one which must be squarely faced and so far as possible in all canal dispositions, discounted. In the Panama situation it is undeniable that each and every structure is a vulnerable point. In the present official scheme on the Pacific side one lock at Pedro Miguel separates the upper Gatun Lake, 27 miles long, at an 85 foot level from Lake Sosa five miles long, at 55 foot elevation. It is so much within the bounds of possibility, even of probability, that an accident may cause the breakdown of the lock gates involving the safety dam at Pedro Miguel, that such a misadventure must not be fatuously ignored. Accidents are not considerate. At the Soo Canal lately the mere suction of the lock-filling sluices has compelled a mandate to approaching vessels to moor at a safe distance. The currents induced by a gate disaster would wrench everything floating from its moorings and convert them into whirling plunging rams. The consequences of this particular accident at Pedro Miguel may be so momentous and appalling that they are certainly to be openly discussed and so far as may be, provided against. With a break of the Pedro Miguel lock gates and the jamming or failure of the safety devices the summit Lake Gatun, 110 square miles in area, would come rushing down into Lake Sosa of eight square miles area, adding the further stress of this accumulating flood. The escape of one foot in Lake Gatun would suffice to raise Lake Sosa about fourteen feet. The thirty feet of difference in elevation of Lake Gatun would suffice to lift Lake Sosa over 400 feet—to over-top its three Pacific dams a dozen times or more. This gives some conception of the amount of water which this situation involves. Accumulation dare not be hazarded because the 55 foot Lake Sosa is above the natural defences of the hills and Panama City right under the breastwork, is at the mercy of the Corozal dam. One of two outlets therefore must be at once provided,—either the western dam across the Rio Grande must be desperately dynamited and a safety channel made there, or the Sosa locks must be opened. But opening the latter would be soliciting a further disaster for the cataract of such a volume falling the height of the first Sosa lock would speedily tear out the lower lock and the whole flight must go the way of destruction. The plan provides practically nothing to interpose safety till the Upper Lake had all but emptied itself into the Pacific Ocean. The velocity occasioned through the Culebra Cut must be one absolutely destructive to its unlined slopes which must be undermined, thus toppling the flanking hills down into the channel beneath. The canal would be ruined—with Culebra swept to Ancon. The entire Pacific section of the water way with its immense system of locks, and the Culebra Division which will have cost a treasury, are thus seen to hang on a missed signal at one gate.

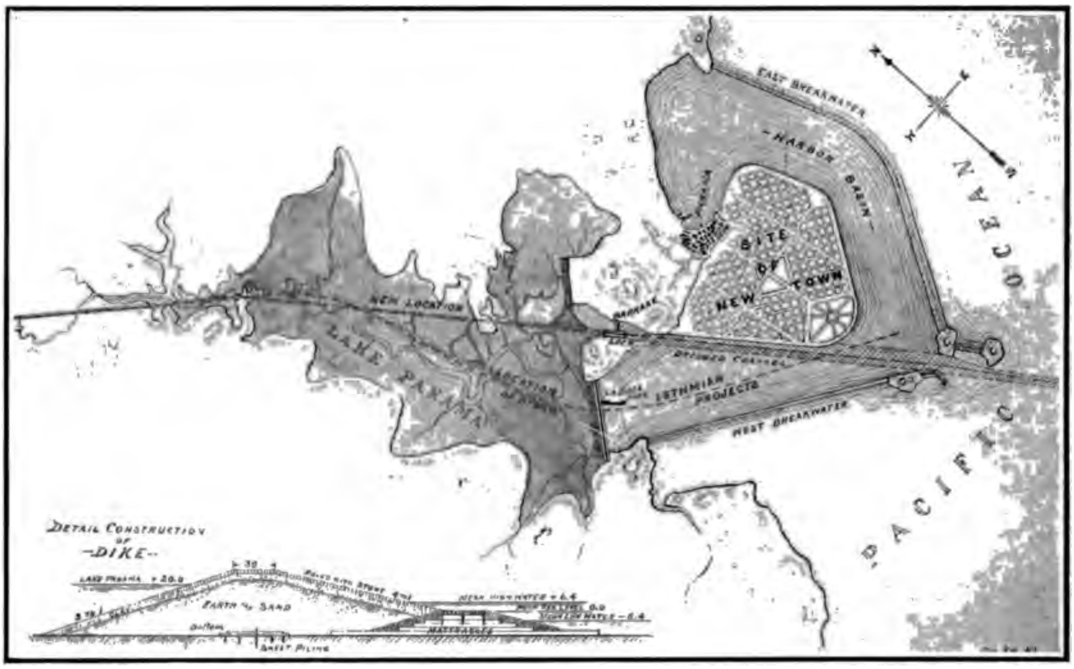
Is the " American " engineering of the combined Minority and Commission to repose in such a suicidal solution as this for a world Canal?

When the level of the lake is lowered to the 26.5 feet originally proposed, this courting of cataclysms is eliminated and the consequences and even possibilities of an accident are largely done away with. The undermining of these vast alluvial-founded dams, not difficult under a 55 to 65 foot head, is for practical purposes impossible with a scientifically built structure required to stand against only the low head.

In case of earthquake three high earth dams pressed by a 55 to 65 foot head would surely be much more susceptible and perilous than a low dyke and a low rock-founded barrage. In the other case of a fatal breach, the results with the dyke and low lake could not for an instant compare with the high lake disaster. A breach in the high Corozal dam means a repetition on an absolutely unparalleled scale of what happened at Johnstown.

A break in either of the two low regulating works would if such could occur, only let the lake pour itself directly into the sea, far away from Panama City. But a serious accident against these advised low structures is impossible, because while the high dams are earth and without sluices the low masonry barrage was especially designed to cope with such contingencies and besides the level of the 26.5 lake is below the natural line of the encircling and safeguarding hills.

This low Lake Panama is therefore self evidently for very many vital reasons a restoration, which the first and barest consideration of ordinary safety dictates.



THE HARBOR AND RECLAMATION OF GREATER PANAMA.

Lake Panama at the 26.5 ft. elevation, giving an inner fresh water harbor. The utilization of Culebra excavations to reclaim the harbor flats and make enclosing breakwaters. The straight alignment passing through Ancon Lock.

THE COST OF THE PACIFIC SECTION OF THE PANAMA CANAL.

Though the case for a low level lake Panama might rest with the demonstration of its pre-eminence in the single points of technical superiority and security, the added considerations of facility of construction and lessened cost of execution, compound its claims. It will become patent upon presentation of the facts that the scheme of three Pacific dams breaks down in the test of practicability of construction and cost as well as in that of desirability.

For a first comparison, the quantities that go to make up the impounding structures of the high lake may be measured up against those which fulfil a similar duty for the lower lake. The 55 foot Sosa Lake dams, three in number, are 80 feet high and 1,180 feet wide at the bottom. Contrast to this the small works which will impound the lake at 26.5 feet! To create the low level lake with a safe impounding structure, there is required but one-ninth of the material demanded by the other. Then again the fifty-five foot lake level is so high that the natural rim of the Rio Grande basin must be raised. So that a crest length of three huge dams no less than 12,150 feet (over 2.3 miles) is required. For the lake at the 26.5 foot level the two natural gaps alone need be closed involving a dyke and barrage totaling 4,950 feet, or two-fifths of the crest length required by the higher lake. The import of these factors is that to impound the 55 foot lake, no less than 12,280,000 cubic yards of earth must be slowly heaped up with a cost estimated by the Minority at $3,170,000. The impounding structures of the 26.5 foot lake contain but 1,421,000 cubic yards of material or, as was noted, one-ninth the volume, and the cost including the masonry sluices barrage is less than one-fourth as great. Here therefore on a primary item—the dams—there is an expenditure by the adoption of the high level lake of four times what the better system would entail.

The next main element of excess in expense is that of rebuilding the Panama Railroad, far back among the hills. It will be driven from its present site as this will be flooded out by over twenty-five feet of water on the roadbed. Lake Panama at 26.5 feet does not disturb the present alignment. But with Lake Sosa at 55 feet above M.S.L., there is therefore compelled this vast expense, for regrading and re-building the road along a new location in the jungle behind Corozal.

These then are two items of the large difference in cost weighing against the high lake plan. The additional cost of its three locks over the two of the low lake (a price of one lock),is partly offset by lessened excavations but on the two features of dams and railroad the advantage is plain and unmistakable.

The official unit prices and estimates of the Minority are tabled.

85 foot Project. Lake Sosa 55 feet.

	Quantity cu. yds.	Unit Cost.	Amount.
Pedro Miguel (one pair of locks) 900 feet long.			
Excavation of earth	650,000	40	$260.000
Excavation of earth	650,000	40	$260,000
Excavation of rock	520,000	1.15	598,000
Locks complete except excavation and approach			5,935,000
Approach			300,000
Back fill and embankment	390,000	50	195,000
Dam: Embankment	1,100,000	25	275,000
Miscellaneous			50,000
Pedro Miguel to Sosa excavation	1,460,000	25	
	220,000	25	420,000
Sosa locks (two pairs in flight)			
Excavation earth	480,000	40	192,000
Excavation rock	950,000	1.50	1,425,000
Locks except excavation and approach			11,000,00
Approach			450,000
Back fill	950,000	50	475,000
Dams: Ancon-Sosa-Corozal (2)	5,980,000	25	1,495,000
La Boca (1)	6,300,000	25	1,675,000
Diversion channel and regulating works	100,000		275,000
Extra at dam sites			150,000
Panama Railway	7 miles	30,000	210,000
Lock Safety Dam			1,000,000
			$26,380,000

Similarly reckoned the arrangement of a 26.5 lake, with one lock at Sosa and two in the Pedro Miguel-Miraflores section totals $25,024,000.

The cost of the low lake system, one lock at Pedro Miguel and one at Sosa totals $20,209,000.

As a matter of arithmetic therefore it is conclusive that the adoption of the high level Lake Sosa and its imperative three great dams adds over five unnecessary millions to the canal cost, even allowing to the proposers the license of their own unit figures for both projects. But for the main structures, unit prices will in fact be materially lower in the 26.5 foot arrangement. It costs much less per cubic yard to raise material into a low dam than into a high one. It is a simpler undertaking to make isolated locks than a flight. There is besides, the practicability of filling in by hydraulic methods which reduces unit costs to the lowest, while the Lake Sosa dams are to employ experimental processes which always mean luxurious deficits. So the lower and simpler construction will be built with much greater ease at markedly lower unit prices, even though (forced by the impracticability of their hydraulic process) Culebra spoil should be substituted and be re-lifted to fantastic heights.

In the face of such deplorable failures as the Minority plans represent here at Panama, it becomes necessary to analyze not alone the low lake proposal, but every other possible substitute. To support at any odds one particular idea would be too much like the official modus to appeal to impartial minds. It must be neither high nor low for or in itself—it must be the right and best Pacific section for the canal. Let us take a complete view therefore and pick the best from whatever source.

It is readily seen that for a canal of two or three Pacific locks there are four available general combinations.

1. One Sosa lock and one Pedro Miguel lock—the canal herein advocated with the summit level at 62.5 feet.
2. Two Sosa locks in flight and one at Pedro Miguel—the system of the Minority's 85 foot canal.
3. One Sosa lock and two in the Pedro Miguel—Miraflores section—the lock alternative of the 85 foot plan.
4. No locks at Sosa; three in the Pedro Miguel—Miraflores section—the Pacific section plan of the 1901 Commission.

There might, it is true, be the further arrangement of a 55 foot canal made by leaving off the Pedro Miguel locks and upper level of the Minority's plan. But retaining as it would the worst features of the three high dams, it is out of practical consideration. There are other two-lock combinations, but having regard to cost it may accurately be said that the above represent all the practicable lock variations. Of these four, the Minority's and the advocated low-lake system, have been treated with some detail. The other two are of import because of announcement from the Isthmus that to one of them the Commission is now turning as an escape from the recommendation of the Minority here—the project to which they so recently subscribed and which they so ingeniously buttressed before the Senate Committee. The exigency of being brought squarely up against the practical problem of execution, seems to be making manifest the need for a change in plan at Panama.

The Lock Canal at Panama.

A scheme which would, in effect, group into a second flight all three locks of the Pacific section, duplicating the deprecated combination at Gatun, is reported to be now under contemplation as the hydraulic panacea by the Commission. The installation of three locks in tier, besides being universally recognized as the most perilous arrangement, would leave here for 5½ miles the entrance channel and the terminal harbor harried by the twenty-foot tides of the Pacific, which already run to 2.2 knots per hour with the present tidal prism. The disposition would compel also in this end section, the costly excavation of a large amount of submerged rock and other refractory material. Its hazardous assets would hardly be supposed by anyone to compensate the loss of unrestricted navigation through a Terminal lake, the drowning of the low-lying fever swamps and the acquisition of an inner tideless fresh-water harbor just within the first lock.

A further and most vital reason against a change of plan to this particular alternative, is that it would raise the cost of the section to $36,361,408, which is $10,000,000 beyond the estimate of the present 85 foot dispositions on which the last appropriations were based, using the unit figures of the Board of Consulting Engineers. This particular lock combination would bring the cost to some $17,000,000 more than the Pacific section of the low level lake herein advocated.

This second, in effect, three-lock Pacific variant was studied by the full International Board and condemned by both factions. Page 78, Report of Minority, reads: " A variant has been studied and estimated upon having the terminal lock at Miraflores 3.6 miles inland, but it is not recommended because it costs much more and is less favorable for navigation."

Page 55, Report of Majority, considers this alternative at length and gives a succession of reasons for eliminating it—" this maximum depth of excavation must be carried " and its " incident cost " . . . " much more curvature than is desirable for a canal entrance, etc.," avoidance of tidal currents which are " undesirable for the navigation of large steamers and would be entirely avoided by the location for the lock adopted by the Board." " Greater cost in dredging to maintain it, etc."

The International Board was useful, apparently, chiefly that the Secretary and Commission and Chief Engineer might be kept in ninepins.

The fourth alternative is that, in which Lake Panama is created at the low plane, but the summit level is set at 85 feet and is reached by two locks in the Pedro Miguel-Miraflores division. It conserves the invaluable advantages of Lake Panama without the perilous extremes of the high level plan. Objections to this newest feature are founded solely in the collective undesirability of three locks, when two suffice; of two upper locks close together, and of the superfluous lift and head of 22.5 additional fee.t Further, an 85 foot summit level is undesirable for reasons especially potent at the Gatun location. So this last arrangement of three Pacific locks as part of an undesirably high level system is deprecated, though it is the best Terminal arrangement for an 85 foot level canal, and is precisely the Project B′ of the Bates plans. The cost of the latter combination figures $25,024,000—materially less than the Minority's arrangement, but over $5,000,000 above the cost of the Pacific section in the 62.5 foot level canal.

As a summary it is clear that in technical superiority and in expense the best Pacific dispositions are attained under a Lake Panama system at an elevation of 26.5 feet, impounded by a scientifically constructed dyke and a safety-sluice barrage—the lake to be entered by one 1,000 foot lock at Sosa and lifting to a 62.5 foot summit level by the second 1,000 foot lock at Pedro Miguel.